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Commonwealth Scientific Conference

LAST Friday a delegation from the United Kingdom, under the leadership of Sir Ben Lockspeiser, F.R.S., Secretary of the Department of Scientific and Industrial Research, left this country by air to attend the British Commonwealth Scientific Conference, which is to be held in Melbourne, Australia, from February 18th to March 4th. The principal object of the conference is to further collaboration in research throughout the British Commonwealth, and all the self-governing countries of the Commonwealth will be represented. The United States Government is sending observers to the conference. The spreading of information and increasing personal contacts between scientists are fundamental to all forms of collaboration in research, and the conference will review the existing facilities and machinery for attaining those objectives and will make general recommendations, where necessary, for their improvement. The conference will also examine a number of subjects which have been suggested as possible topics for collaboration. The industrial subjects to be put forward for consideration include industrial microbiology, the utilisation of seaweed, research on metal casting, sulphur production, the utilisation and beneficiation of low-grade ores and wastes, research on wool fibre, soil mechanics, and the utilisation of solar energy by physical or biological means. Another matter which is to be discussed at the conference is relations with international research organisations. Preparations for this conference have been going on for the past eighteen months under the guidance of the standing committee, which was set up at the 1946 conference and which consists of the heads of the official research organisations throughout the Commonwealth.

Cast Iron Production

AT the end of last week the Council of Ironfoundry Associations issued a statement in reply to a suggestion made recently by the British Iron and Steel Federation that the quantity of raw materials used last year in the production of iron castings contributed to the failure of the steel industry to achieve an output of 16,000,000 tons. The Federation also suggested that the output of iron castings should be kept at the 1950 level of 3,500,000 tons until steel production could be restored to the 1950 figure. The statement by the Council of Ironfoundry Associations pointed out that, last year, imports of steelmaking scrap fell by 1,340,000 tons. If that figure, it asserted, was compared with the extra amount (237,000 tons) of pig iron and scrap used by the iron foundries last year, it could be seen that the failure of the steel industry to reach its target was due principally to the shortage of foreign scrap and not to the increase in the quantity of iron used by the foundry industry, which amounted to about one-sixth of the decline in imported scrap. Another point emphasised in the Council's statement was that in order to reach an output in 1951, estimated at 3,750,000 tons, the iron foundries had to reduce their stocks of pig iron by 180,000 tons and were now working on a hand-to-mouth basis. There was a growing demand, the statement continued, for cast iron products in connection with the housing programme and from such important sections of industry as railways, machine tool, textile machinery, motor-car and agricultural machinery manufacturers, whilst ingot moulds for the steel industry itself took over 9 per cent of the iron foundries' output. At a time when the steel industry is in process of denationalisation, the Council of Ironfoundry Associations —which represents 70 per cent of the total output of the ironfoundry industry—has deemed it essential to stress the necessity for maintaining its continuing right to obtain adequate raw materials. Mr. N. P. Newman, chairman of the Council, who presented the statement, agreed that it was a matter of national concern that "the difference of opinion between the two industries should be sensibly resolved."

Co-operative Research in the Electrical Industry

WE learn that the Electrical Research Association has made an appeal to its members for a 20 per cent increase in their annual subscriptions and for contributions to meet the cost of building the new laboratories. The E.R.A. points out that, to ensure continuance of the Government grant and to maintain and increase the present research programme requires an immediate increase of 20 per cent in the annual subscription. To allow for capital expenditure on the Leatherhead laboratories a special contribution, equal to twice the annual subscription, is required, either in a lump sum or spread over two years. As far as revenue is concerned, it may be recalled that the Government grant to the E.R.A. is the subject of five-year agreements. At the last quinquennial review it was evident that the Industrial Grants Committee of the Department of Scientific and Industrial Research felt that co-operative research was not being developed in proportion to the size and importance of the industry. As an incentive to the industry to maintain and expand its co-operative research activities, the D.S.I.R. has therefore modified the terms of the Government grant for the next five year period: the effect is that, although the maximum grant that can be earned is increased, the minimum subscription income necessary to qualify for the grant has also been increased. Thus, in 1949–50 the grant-earning income was £113,000, which earned the maximum grant of £70,000, making a total of £183,000. In 1950–51 the subscription income may have approached £120,000, making a total, with grant, of £190,000. The same subscription income in 1951–52 would, it is pointed out, attract only £50,000 grant, and the reduced total of £170,000 would clearly prejudice the continued existence of the E.R.A. On the other hand, by increasing the subscription income to £170,000, thereby earning the new maximum grant of £100,000, the total would be £270,000. On the subject of the building fund the E.R.A. points out that the estimated cost of the buildings at Leatherhead is £400,000, of which at least half must be sought from the members collectively.

The Security of Locks and Safes

AT a meeting of the Royal Society of Arts, which was held in London on Wednesday of last week, an interesting paper entitled "Security Offered by Locks and Safes," was presented by the Hon. George C. H. Chubb. It touched upon developments in lock-making, and also pointed out that lock "picking," like lock-making, was a specialist's art, far removed from the exploits described in fiction! Mr. Chubb made particular reference to keyless combination locks, which, he said, were first invented in the U.S.A. in the middle of last century. Many improvements in them had followed, including the dial check lock, which prevented any unauthorised manipulation of the dial. The majority of keyless combination locks, Mr. Chubb explained, had four wheels, each of which could be set at any number from one to a hundred, the total number of different combinations possible being just short of 100,000,000. But the most expensive lock in the world to-day, the paper stated, was the time lock, invented in 1873, which, when fitted to a safe or strong-room ensured that nobody could open the door until a certain time had elapsed. That was achieved by the incorporation of from two to four clock movements, which, at the predetermined time, released the mechanism and enabled the main bolts of the safe to be operated. Dealing with the subject of safes and strong-rooms, Mr. Chubb mentioned the safebreaker's equipment, commenting that the safebreaker's failure was usually due to any one of a combination of three causes—lack of skill, lack of implements, or lack of time. Describing safe construction, he said that concrete strong-rooms were quite frequently made in block formation, so that they could more easily be assembled on sites where the facilities for concrete construction were not easily available. The blocks, which contained both structural and "burglar" reinforcement, were so designed that they interlocked with each other.

Launch of "World Concord"

ON Tuesday of last week, the 31,000-ton deadweight oil tanker "World Concord" was launched from the Barrow yard of Vickers-Armstrongs, Ltd., the naming ceremony being performed by the Countess Mountbatten of Burma, who was accompanied by her husband, Lord Mountbatten. The vessel is a sister ship to "World Unity," which was launched from the same yard on October 16th of last year, and both vessels, which are building to the order of the North Atlantic Shipping and Trading Company, have a length between perpendiculars of 625ft by 86ft beam by 45ft 9in depth, and a speed of 15 knots. In proposing the toast of the ship, Sir Ronald Weekes, the chairman of Vickers, Ltd., said that the occasion was historic, since the ship was job No. 1000, and recalled that job No. 1 was a steamship named the "Duke of Devonshire," which was laid down about eighty years ago by the Barrow Shipbuilding Company, Ltd. Continuing, Sir Ronald mentioned the various changes of name of the company and briefly touched upon the history of Vickers-Armstrongs, Ltd., as revealed by the order book. This recorded the building of a wide variety of ships including early composite gunboats for the Royal Navy, the submarine "Nordenfeldt," completed in 1886, and many other naval vessels constructed during both world wars. Many notable merchant ships and passenger liners had been delivered by the yard, and the first oil tanker "Hainaut," now named "Marti," was still afloat after sixty-four years. The record also recalled the airship building activities of the company ranging from the "Mayfly" in 1911, and ending with the "R.80." With reference to the other ships ordered by Mr. S. S. Niarchos, Sir Ronald announced that the order for two tankers of 32,500 tons deadweight had been modified to two ships of 44,000 tons deadweight having a length overall of 757ft by 97ft beam by 52ft depth, and a maximum draught of 36ft, each being driven by a single set of geared turbines developing 20,000 s.h.p. to give the ships a speed of 17 knots. When completed the ships will be the largest oil tankers in the world.

Phenomenological Theories of Creep

By A. GRAHAM, M.Sc., D.I.C. *

No. I

A formula with four adjustable constants relating permanent strain to stress, time and temperature, is shown to represent successfully the decelerating stage of uniaxial creep in several dissimilar metals. It embraces many well-known empirical laws of creep, for non-metals as well as metals, excluding only, so far as is known, laws alternative to those embraced ; and it may be generalised to cover certain anomalies. Its applications to tertiary creep, to the tensile test, and to stress relaxation are considered, together with its limitations as an equation of state. A closely allied formula is then put forward which is hardly distinguishable from the first over a small range of temperature, and for which the state of the metal is not characterised by the instantaneous rate of straining.

AT the present time, those concerned with creep, whether from the engineering, metallurgical, or physical points of view, would probably agree in the need for a working theory which, even though it applied only to ideal cases, could be used, much as elasticity theory is used, as a basis for more realistic considerations. Such a theory is needed by the engineer for stress calculations, by the metallurgist in his search for improved mechanical properties, and by the physicist as a general target at which his fundamental speculations should aim. The discussion in this article may be a step towards this end.

Various quantitative laws of creep have been proposed from time to time which represent with partial success certain restricted aspects of the behaviour of particular materials ; but the complete results of a series of constant-load constant-temperature creep tests, performed over a range of loads and temperatures on one material, do not appear as yet to have been fitted by any simple mathematical scheme. Part reason for the absence of a comprehensive theory is undoubtedly the structure-sensitivity of creep, for while, on the one hand, firm average data must be available fully to confirm or deny a tentative law, on the other, on account of the time and labour involved, the collection of such data by repeated testing is seldom practicable. The vicious circle, however, is not entirely closed. Because of structure sensitivity, together also with metallurgical factors, laws of the 100 per cent order of validity are not to be expected, so that creep investigations must always be recognised as statistical. Exact use of inexact ideas, which is the essence of the statistical method, will thus allow progress to be made.

Because of random factors, the importance of any law of creep is by no means determined by the exactness of its agreement with experiment for one particular material, but is determined rather by the range of materials for which the agreement is, to use a statistical term, " significant." The range of behaviour covered, e.g., for different loading conditions, is also of importance. When general conclusions must be drawn from limited experiments during which several factors may vary, a search must in the first place be made, not so much for rigorous laws with rigorous relationships between them, but rather for probable laws and probable relationships, on the principle that, just as one tentative law increases in significance with the number of materials for which broad agreement is found, so it increases also in significance with the number of other tentative laws with which connections may be established. Exact connections, of course, carry most weight, but even qualitative ones increase the statistical significance of the whole. Although very reasonable quantitative agreement may be claimed for the phenomenological theories developed in this paper, their strength derives rather from the range of materials and conditions to which they broadly apply.

When search is made through the literature for the most probable laws of creep, the merely descriptive empirical type should clearly be avoided ; but not all of them are easy to recognise. Many of the near-fundamental laws of physics, for example, such as those of Hooke and Ohm, were purely empirical when originally put forward, and by this token an empirical law may ultimately have more worth, despite its smaller prestige, than a seemingly rational law : " seemingly " because all forms have their empirical content. There is no immediate guide ; but formulæ of either kind that involve more than the minimum number of adjustable constants must be viewed with suspicion. Close representation with few constants is not necessarily to be expected ; but the initial procedure with the highest expectation of success is that which errs on the side of choosing too few constants rather than too many, but which takes care at the same time to have separate physical processes separately expressed.

Assumptions

For a material of fixed composition, the primary variables are stress σ, strain, temperature T, and time t, the latter being involved in the rates of change of the other variables and also explicitly. Strain may be logically separated into the physically distinct elastic and plastic (creep) components e and ϵ, corresponding respectively (for point atoms) to deformations in which the spacing of the atoms changes, but not their arrangement, and vice versa. The measure of the former is taken to be $\Delta l/l_o$, and of the latter $\int_{l_o}^{l} \frac{dl}{l}$. For a material stabilised by the appropriate treatment prior to testing, the assumption is often made that t is not present explicitly, the primary variables being then σ, ϵ, $\dot{\epsilon}$, and T. Time is involved implicitly in the variable $\dot{\epsilon}$. Elastic strain is included in σ through Young's Modulus E, and the rates of change of σ (i.e., of elastic strain) and T are assumed to be unimportant. Later in this paper the alternative assumption is tried that time occurs explicitly, the primary variables being then σ, ϵ, t, and T.

So-called " equations of state " in the first set of variables have been proposed and put to the test by experiments that attempt to take the material from one given condition to another by two different strain-time-temperature paths[1,2,3,4]. They have usually failed ; and in so far as the conditions and variables chosen are representative of those of engineering practice, they show not merely that the assumption of an equation of state for plastic behaviour, i.e., of a unique relationship between the four variables, is unwarranted, but also that the common procedure of designing, on the basis of the usual creep test results, for the non-simple stress/time conditions in an actual machine, is unsound. However, these considerations do not arise, if, as in the next few paragraphs, the results of creep tests alone are to be represented by a mathematical formula.

The tertiary stage of creep leading to fracture has been attributed to such processes as over-ageing, recrystallisation, cracking, and corrosion ; and if these are left out of account for the moment, and the so-called steady stage of creep is regarded as merely a prolonged transition to a tertiary stage, it is not unreasonable, with the objectives of the opening paragraph in view, to represent the creep curve by the formula

$$\epsilon = bt^n, \ (\sigma, T) \text{ constant} \quad . \quad . \quad (1)$$

in which b and n are constant. This is often valid for metals (see, e.g., references[5, 6, 7, 8]), and has the further virtue, according to the principles of the first paragraph, of including the minimum number of constants. The dimensional objections that have been raised against power formulæ of this kind have been met by Scott Blair and by Dingle.

Soderberg[9] has proposed a law concerning the effect of a change of stress which has received published confirmation from independent sources[9, 10] and is frequently employed in creep laboratories. It is that the various strain/time curves at a single temperature for different constant stresses are geometrically similar, in that all may be superimposed by suitably choosing the strain scale for each curve. This implies that n in (1) is independent of σ.

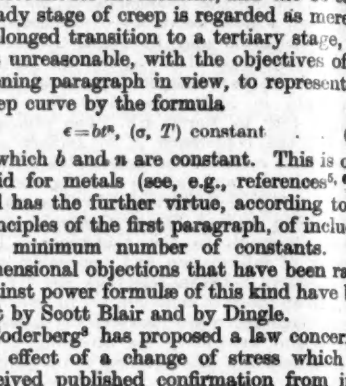


FIG. 1

Several authors have discussed how the strain rate $\dot{\epsilon}$ varies with temperature. MacGregor and Fisher[11, 12] have provided considerable experimental support for the opinion that any change in the one may be exactly compensated by a change in the other by establishing their parameter

$$T_m = T\left(1 - k \ln \frac{\dot{\epsilon}}{\dot{\epsilon}_o}\right) \quad . \quad . \quad . \quad . \quad . \quad (2)$$

in which the two variables are combined into one. In this, k and $\dot{\epsilon}_o$ are constants, the latter being freely chosen, $\ln$ is the natural logarithm, and T is in degrees absolute. The four variables in the problem are thus reduced to three, related symbolically by

$$\sigma = f(\epsilon, T_m) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

They have justified this form, by experiments in which plastic strain increases con-

* National Gas Turbine Establishment, Whetstone, Leicester.

tinuously, for a variety of materials, temperatures, and rates of straining. It should be noted, however, that according to their interpretation, the symbol ϵ in (3) is the total strain and not, as here, solely the plastic strain.

The final assumption to be made concerns the form of the right-hand member of (3). Temperature is usually introduced into formulæ for creep through a factor $e^{-Q/RT}$; however, an expression of this kind is already incorporated in T_m; for MacGregor and Fisher derived their parameter from the assumption due to Zener that, when σ and ϵ are constant,

$$\dot{\epsilon}e^{Q/RT}=\text{constant} \quad . \quad . \quad . \quad (4)$$

The former authors' results, which relate to several steels, brass, and aluminium, suggest that the relation is complex in general; but outside the range of effects like blue-brittleness in steels, for example, the general fall of stress with T_m at constant ϵ appears to be well represented by

$$\sigma=ce^{-dT_m} \quad . \quad . \quad . \quad . \quad (5)$$

in which c and d are constants. This is supported by the fact that Schischokin[13] has proposed a similar relation to represent the variation of hardness and flow stress (Flieszdrück) with temperature; but, in general. it is certainly an over simplification.

The laws chosen may be combined together, much as other laws have been combined by other workers (e.g., Hollomon and Lubahn[2]), into a single formula. This is most readily done by considering how k is to be determined from experimental results.

Theory

Equation (3) may be represented as the family of curves shown diagrammatically in Fig. 1*a*. If σ and ϵ are given fixed values, say, σ_a, ϵ_a, then T_m will have the fixed value T_{ma}, and the same combination σ_a, ϵ_a, will occur for different pairs of values, T_1, $\dot{\epsilon}_1$, T_2, $\dot{\epsilon}_2$, of temperature and strain-rate in accordance with (1), i.e., pairs for which

$$T\left(1-k\ ln\frac{\dot{\epsilon}_1}{\dot{\epsilon}_o}\right)=T_2\left(1-k\ ln\frac{\dot{\epsilon}_2}{\dot{\epsilon}_o}\right)=\ldots$$

By eliminating t from (1) we have

$$\dot{\epsilon}=nb^n\epsilon^{1-\frac{1}{n}} \quad . \quad . \quad . \quad . \quad . \quad (6)$$

so that, since b and n will be different for each pair,

$$T_1\left(1-k\ ln\frac{n_1b_1^{\frac{1}{n_1}}\epsilon_a^{1-\frac{1}{n_1}}}{\dot{\epsilon}_o}\right)=T_2\left(1-k\ ln\frac{n_2b_2^{\frac{1}{n_2}}\epsilon_a^{1-\frac{1}{n_2}}}{\dot{\epsilon}_o}\right),$$

$$T_1-T_2=kT_1ln\frac{n_1}{\dot{\epsilon}_o}-T_2ln\frac{n_2}{\dot{\epsilon}_o}+T_1ln\left(b_1^{\frac{1}{n_1}}\epsilon_a^{1-\frac{1}{n_1}}\right)-T_2ln\left(b_2^{\frac{1}{n_2}}\epsilon_a^{1-\frac{1}{n_2}}\right) \quad . \quad (7)$$

If k is to be determined from this equation, it must have the same value, however σ_a and ϵ_a are initially chosen. If we regard T_1 and T_2 as decided, n_1 and n_2 will be decided, and the first two terms on the right will be the same whatever the choice may be. The remaining terms, however, will depend in general upon the free choice of ϵ_a and, since b varies with σ, upon the independent choice of σ_a. Since this cannot be allowed,

$$\frac{T_1}{n_1}ln\ b_1-\frac{T_2}{n_2}ln\ b_2$$

and

$$T_1\left(1-\frac{1}{n_1}\right)ln\ \epsilon_a-T_2\left(1-\frac{1}{n_2}\right)ln\ \epsilon_a$$

must depend only upon T_1 and T_2, i.e.,

$$\frac{T_1}{n_1}ln\ b_1-\frac{T_2}{n_2}ln\ b_2=A \quad . \quad . \quad . \quad (8)$$

and

$$T\left(\frac{1}{n}-1\right)=B \quad . \quad . \quad . \quad . \quad (9)$$

where A is a constant which depends on T_1 and T_2, and B is a constant for the material. Because n is less than unity in the primary and secondary ranges, B is a positive quantity. Using these results in (7) we find

$$k=\frac{T_1-T_2}{T_1ln\frac{n_1}{\dot{\epsilon}_o}-T_2ln\frac{n_2}{\dot{\epsilon}_o}+A} \quad . \quad . \quad . \quad (10)$$

Along any line of constant stress in Fig. 1*a* consider two states having different strains ϵ_a ϵ_b and velocity modified temperatures T_{ma}, T_{mb}. Let T be the same in both, and the strain rates be $\dot{\epsilon}_a$ $\dot{\epsilon}_b$. Then

$$T_{ma}=T\left(1-k\ ln\frac{\dot{\epsilon}_a}{\dot{\epsilon}_o}\right),$$

$$T_{mb}=T\left(1-k\ ln\frac{\dot{\epsilon}_b}{\dot{\epsilon}_o}\right),$$

so that, from (6), since b and n are fixed with T and σ,

$$T_{mb}-T_{ma}=Tk\ ln\frac{\dot{\epsilon}_a}{\dot{\epsilon}_b}=Tk\ ln\frac{nb^n\epsilon_a^{1-\frac{1}{n}}}{nb^n\epsilon_b^{1-\frac{1}{n}}}.$$

or, from (9),

$$T_{ma}-T_{mb}=Bk\ ln\frac{\epsilon_a}{\epsilon_b} \quad . \quad . \quad . \quad . \quad . \quad (11)$$

The separation, parallel to the axis of T_m, between two curves for constant ϵ in Fig. 1, is therefore constant throughout their length, i.e., all curves in the figure have the same form.

For the curve ϵ_o, the constants c_o and d_o, say, in (5), are determined when two (σ, T_m) co-ordinates are given, say, (σ', T_{mo}'), (σ'', T_{mo}''), in Fig. 1*b*; thus

$$d_o=\frac{ln(\sigma'/\sigma'')}{T_{mo}''-T_{mo}'}.$$

Similarly, for any other curve ϵ and the same two stresses

$$d=\frac{ln(\sigma'/\sigma'')}{T_m''-T_m'}.$$

In view of (11), therefore, d is the same for all curves and a constant for the material. For curves ϵ_o and ϵ at the same stress σ we now have from (5),

$$ln\ \sigma=ln\ c-dT_m=ln\ c_o-dT_{mo}$$

in that, by (11),

$$c=c_o\left(\frac{\epsilon}{\epsilon_o}\right)^{dBk},$$

or if

$$c_o\epsilon_o^{-dBk}\equiv\sigma_s,\ dBk\equiv m,$$

$$c=\sigma_s\epsilon^m.$$

Thus (5) becomes

$$\sigma=\sigma_s\epsilon^me^{-dT_m}=\sigma_s\epsilon^mexp\left[-dT\left(1-k\ ln\frac{\dot{\epsilon}}{\dot{\epsilon}_o}\right)\right] \quad . \quad . \quad . \quad . \quad . \quad (12)$$

in which σ_s m d and k are constants of the material, the latter depending upon the arbitrary $\dot{\epsilon}_s$. It may be written in the non-dimensional form

$$\frac{\sigma}{\sigma_s}=\epsilon^m\left(\frac{\dot{\epsilon}}{\dot{\epsilon}_s}\right)^{qT} \quad . \quad . \quad . \quad . \quad (13)$$

so which $\dot{\epsilon}_s=\dot{\epsilon}_o\ exp\frac{d}{q}$ and $q\equiv kd$,

with the advantage that an arbitrary constant disappears and the dimensions of the four constants σ_s $\dot{\epsilon}_s$ m and q are readily seen.

This formula is seen to be a special case of that of Hollomon and Lubahn.[2] Before its implications are considered in detail, however, a comparison will be made with experimental data for several commercial and other materials in order to establish that further discussion is likely to be of practical value.

Comparison with Creep-Test Data

Direct experimental creep data, particularly for engineering materials, covering a range of stress and temperature sufficient to establish the constants in (13) are not often published; moreover the suitability of data for present purposes is limited by considerations to be discussed later. That most readily available, the sources of which are given in references 14 to 19, was for nimonic 80, G.18.B, stellite 8, hiduminium RR.59, O.F.H.C. copper, and high-purity lead.

These materials differ completely from each other; nominal compositions of the alloys are :—

Table I—*Nominal Compositions of Alloys*

Alloy :	Nimonic 80	G.18 B.	Stellite 8	RR.59
C	0·05	0·40	0·21	—
Si	0·70	1·38	0·34	0·91
Mn	0·38	0·89	0·02	0·01
Ni	Bal.	13·5	—	1·09
Cr	21·24	13·5	30·7	—
Fe	3·03	Bal.	0·4	1·12
Co	—	10·6	Bal.	—
Ti	2·83	—	—	0·07
Al	0·04	—	—	Bal.
Mo	—	1·83	6·14	—
W	—	2·42	—	—
Nb	—	2·80	—	—
Cu	0·11	—	2·15	—
S	—	0·02	—	—
P	—	0·02	—	—
Mg	—	—	1·42	—

The tertiary stages were disregarded when the constants in (13) were determined. Values found for σ_s, m, $\dot{\epsilon}_s$, q, B are given in Table II, together with those for k and d corresponding to the arbitrary $\dot{\epsilon}_o$ figures shown. The strain/time relations appropriate to these constants were recalculated from the explicit expression for ϵ, corresponding to (1), which must be obtained from (13) by integration with respect to time from the limit $\epsilon=o$ when $t=o$; it is

$$\epsilon=\frac{1}{n^n}\left(\frac{\sigma}{\sigma_s}\right)^{\frac{n}{qT}}(\dot{\epsilon}_st)^n \quad . \quad . \quad . \quad (1a)$$

in which

$$n\equiv\frac{qT}{m+qT},\ \text{and}\ \left(\frac{\dot{\epsilon}_s}{n}\right)^n\left(\frac{\sigma}{\sigma_s}\right)^{\frac{n}{qT}}\equiv b,$$

n and b being the constants of assumption (1). Original and recalculated data are compared in Figs. 2 to 5 and Tables III to V. In the figures experimental results are shown in full line, while the broken lines represent, essentially, the experimental data smoothed

Table II—*Collected Values of Constants*

Constant	Nimonic 80	G.18 B	Stellite 8	Copper	RR.59	Lead
σ_s	15,700	22,300	87,800	133	16,500	4·73
$\dot{\epsilon}_s^{-q}$	0·9964	0·99575	0·997	0·989	0·99555	0·98735
m	0·125	0·197	0·10	0·408	0·299	0·054
q	0·000132	0·000134	0·000325	0·000523	0·000322	0·000455
k*	0·046	0·048	0·08	0·051	0·063	0·07
$\dot{\epsilon}_o$	10^{-10}	10^{-7}	10^{-9}	10^{-11}	10^{-10}	10^{-7}
B	950	1,470	290	780	930	119
d	0·00665	0·0064	0·0099	0·0237	0·01176	0·0147

Units : Ton, square inch, sec., °K.

* For logarithm to base 10 in T_m.

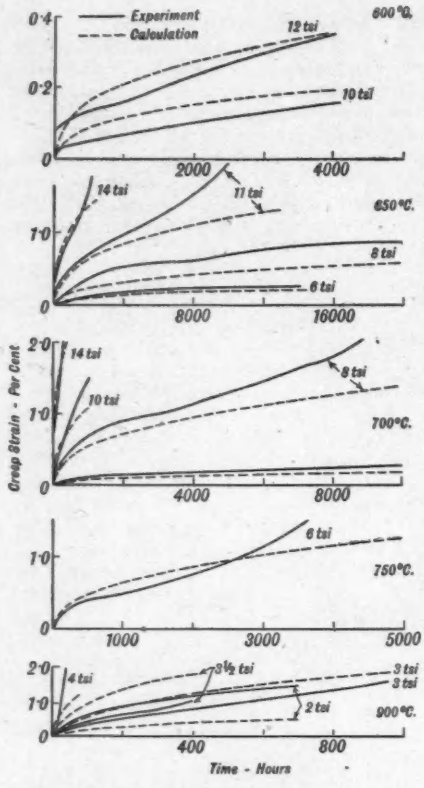


FIG. 2—CREEP CURVES FOR ALLOY G18B

over its range of stress and temperature in accordance with theory.

The range of variation over the different materials of some of the constants in Table II needs some comment. With four constants to determine from limited and irregular data, the value of any one, considered individually, is much less precisely determined than the values of the four together considered as a group. Thus, while the overall strength level of the material may be well established, the specific influence of any one of the variables on the stress level may be very indefinite. The number of significant figures given in the table is necessary to maintain the relationship between the variables, but should not be taken to indicate the precision of the individual values. These considerations illustrate very clearly the slender support that restricted experiments may give to formulæ with many free constants, and fully justify the point of view of the introductory paragraph.

Detailed comments are below, but it is seen at once that discrepancies lie broadly within those normally expected in creep-test results. Independent evidence on this is afforded by the results of some comparative 3000-hour tests arranged by the American Society for Testing Materials in seven different laboratories on the most uniform material available at the time, namely, a 0·35 per cent carbon steel.[20] The log strain/log time plots do not depart significantly from the linear form required by (1). Values of n and b show considerable random scatter, the extreme range for n being about 30 per cent of the mean and, for b, 300 per cent. Unfortunately, these careful experiments were mainly done at a single temperature and are thus of no use for a full comparison with the theory.

Nimonic 80[14, 15] (*Fully Heat-Treated*).—Creep performance is commonly specified in terms of the stress to produce a chosen strain at given time and temperature, and a table of this kind has been given by the Mond Nickel Company.[2] It is based upon tests of over ten times the duration of those that were immediately available to determine the constants for this material, and it includes results obtained at the additional temperature of 750 deg. Cent. It is here partly reproduced as Table III, which also includes values calculated according to the constants of Table II, together with discrepancies expressed as a percentage of the Mond Nickel values. The strain of 0·5 per cent in the firm's table is well in the tertiary range and is discussed in para. 7 below. Very reasonable agreement is shown over the primary and secondary ranges, particularly since the figures for 750 deg. Cent. and for 1000, 5000 and 10,000 hours involve extrapolation.

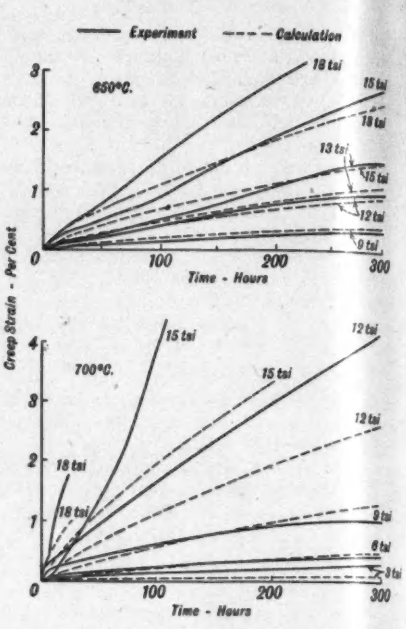


FIG. 3—CREEP CURVES FOR STELLITE 8

G.18.B[16] (*Solution Treated at* 1300 *Deg. Cent.*).—See Fig. 2 and Table IV. Since this

TABLE III—*Nimonic* 80

Time and temperature, deg. Cent.	Mond-nickel values: Stress. tons/in² to produce creep extension of		Values from formula: As percentage discrepancy from Mond-nickel values	
	0·1%	0·2 %	0·1%	0·2%
100 hrs.:				
600 ...	29·5	32·0	− 3·4	+ 5·2
650 ...	21·0	24·5	− 0·5	+ 1·2
700 ...	16·5	19·0	− 7·3	− 4·0
750 ...	10·0	12·5	+12·0	+ 7·2
300 hrs::				
600 ...	25·5	29·0	− 1·6	+ 2·1
650 ...	19·0	22·0	− 3·7	− 1·7
700 ...	14·0	16·5	− 5·0	− 4·0
750 ...	8·0	9·5	+20·0	+ 22·1
1,000 hrs.:				
600 ...	22·0	25·0	− 1·0	+ 2·8
650 ...	16·5	19·5	− 4·1	− 4·1
700 ...	11·0	13·5	+ 3·6	+ 0·7
750 ...	6·0	7·0	+36·7	+ 40·0
5,000 hrs.:				
600 ...	18·0	21·0	+ 0·8	+ 1·9
650 ...	13·5	15·5	− 3·7	− 0·6
700 ...	—	9·0	—	+ 22·2
750 ...	—	(4·0)	—	+ 97·5
10,000 hrs.:				
600 ...	17·0	19·5	− 1·2	+ 1·0
650 ...	12·0	14·0	− 0·8	+ 0·7
700 ...	—	(7·5)	—	+ 34·6
750 ...	—	(3·5)	—	+106·0

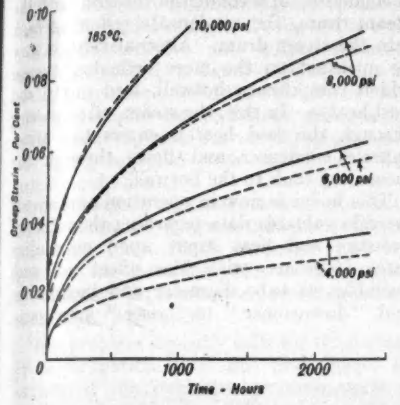
TABLE IV—G.18 B

Time and temperature, deg. Cent.	Stress tons/in² to produce creep extension of: 0·1%	0·5%	1·0%	Values from formula: 0·1%	0·5%	1·0%	Discrepancy, per cent
300-hour data :							
650...	8·0	13·0	15·0	7·66	12·83	16·02	− 4·25− 1·3 + 6·8
700...	4·9	9·3	11·2	5·37	9·1	11·4	+ 9·6 − 2·15+ 1·79
750...	3·6	6·4	7·9	3·77	6·45	8·1	+ 4·7 + 0·78+ 2·53
800...	4·0	5·3	5·7	2·65	4·58	5·8	−33·75−13·58+ 1·75
1,000-hour data :							
650...	6·6	11·4	13·6	6·6	11·05	13·8	0·0 − 3·07+ 1·47
700...	3·6	7·7	9·4	4·6	7·78	9·76	+27·8 + 1·04+ 3·8
750...	3·3	5·9	6·6	3·2	5·5	6·9	− 3·03− 6·78+ 4·55
800...	3·9	4·8	5·0	2·22	3·85	4·88	−43·08−19·79− 2·4
3,000-hour data :							
650...	5·8	7·8	11·4	5·76	9·65	12·05	− 0·7 +23·7 + 5·7
700...	2·7	6·8	8·2	3·98	6·74	8·45	+47·4 − 0·88+ 3·05
750...	3·0	5·4	5·6	2·75	4·71	5·9	− 8·33−12·78+ 5·36
800...	(3·7)	(4·5)	4·7	1·9	3·29	4·16	−48·65−26·89−11·49
10,000-hour data :							
650...	(5·0)	6·4	(9)	4·96	8·3	10·38	− 0·8 +29·7 +15·3
700...	—	6·0	7·0	3·4	5·76	7·2	— − 4·0 + 2·86
750...	2·5	4·5	(5·5)	2·33	4·0	5·03	− 6·8 −11·11− 8·55
800...	—	(4·2)	(4·4)	1·6	2·76	3·5	— −34·29−20·45
30,000-hour data :							
650...	—	(5·8)	(7·0)	4·33	7·26	9·06	— +25·2 +29·4
700...	—	(5·4)	(6·0)	2·95	5·0	6·26	— − 7·4 + 4·33
750...	—	—	—	2·0	3·4	4·3	— — —
800...	—	—	—	1·36	2·36	3·0	— — —

TABLE V—*RR.*59

Time and temperature, deg. Cent.	Stress tons/in² to produce creep extension of: 0·1%	0·2%	Values from formula: 0·1%	0·2%	Discrepancy, per cent
100-hour data :					
150	18·5	(21·0)	18·59	25·1	+ 0·49+ 19·5
200	13·6	16·0	10·9	14·9	− 19·9 − 6·9
250	6·8	9·3	6·2	8·6	− 8·8 − 7·5
300	1·5	2·3	3·6	5·0	+140·0 +117·0
300-hour data :					
150	17·3	20·0	16·01	21·6	− 7·5 + 8·0
200	11·6	14·3	9·1	12·4	− 21·6 − 13·3
250	5·4	7·9	5·2	7·2	− 3·7 − 8·9
300	1·2	1·5	2·9	4·1	+142·0 +173·0
1000-hour data :					
150	15·9	18·3	13·6	18·4	− 14·5 + 0·5
200	9·6	12·5	7·6	10·4	− 20·8 − 16·8
250	4·4	6·4	4·2	5·8	− 4·5 − 9·4
300	—	—	2·4	3·3	— —

material was known to be relatively stronger at 800 deg. Cent. than direct extrapolation from lower temperatures would suggest, and at 900 deg. Cent. the creep curves were less reliable owing, it is understood, to extensometer trouble at this high temperature, the constants were evaluated only from the



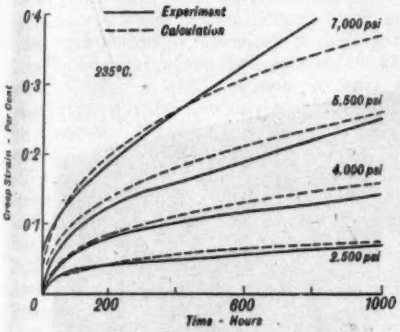


FIG. CREEP CURVES FOR COPPER

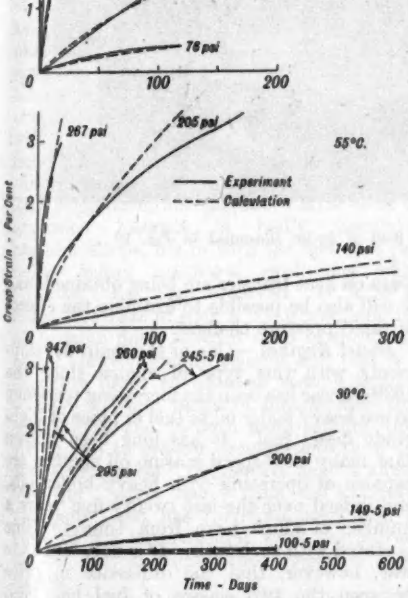


FIG. 5—CREEP CURVES FOR LEAD

600–750 deg. Cent. curves. The strength is underestimated at 800 deg. Cent. as required (Table IV), while behaviour at 900 deg. Cent. is in accordance with the formula in that the broken lines in Fig. 2 represent a reasonable smoothing of the experimental curves.

Stellite 8†; *Hiduminium RR.59* (*Solution Treated and Aged*).[18]—Figures assembled for the guidance of designers were immediately available for these materials, but were rather irregular; comparisons are in Fig. 3 and Table V. There is evidence with both of some time-explicit loss of strength at the highest temperatures.

Copper.[17]—The experimental data refer to O.F.H.C. material prestrained 8 per cent when cold, and comparison is in Fig. 4. The results of Krupkowski and Balicki[21] on the effect of temperature on the mechanical properties of cold-worked copper, when adapted to the longer times at temperature associated with the present experiments by means of a formula established by van Liempt[22], suggest that some recovery may have occurred at the higher of the two experimental temperatures.

Lead.[19]—Comparison is in Fig. 5. In his paper, A. A. Smith remarks that recrystallisation occurred during the high-stress creep tests, but definitely not during the lower stress tests. The figure does not indicate a systematic effect associated with this cause.

In summary, for the materials considered, there is little evidence of systematic departure from the formula apart from those associated with tertiary creep and with the time-explicit changes mentioned.

†For particular casting conditions; properties are very sensitive to mould temperature.

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[18] National Gas Turbine Establishment Data for Cast Stellite 8 and Messrs. High Duty Alloys Data for Hiduminium RR.59. It is understood that the latter is now in course of revision.

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(To be continued)

Ship Research

By S. LIVINGSTON SMITH, C.B.E., D.Sc.(Eng.), M.I.Mech.E.*

No. III—(*Concluded from page 168, February 1st*)

In this Thomas Lowe Gray Lecture presented before the Institution of Mechanical Engineers, on January 18th, which we here abstract, the author grouped the various branches of research under four main headings: ship structures, hydrodynamics, ship performance and ship machinery, respectively. He selected for reference the more important and interesting examples of research under each heading.

SHIP MACHINERY

Steam Turbines.—In regard to Great Britain, one of the most momentous steps in the history of the marine turbine was taken in 1944 with the formation of the Parsons and Marine Engineering Turbine Research and Development Association (Pametrada), which is supported by the collective effort of all the shipbuilding and engineering firms manufacturing marine turbines in British shipbuilding centres. This association is energetically conducting research into numerous problems concerning the marine application of both steam and gas turbines, together with transmission systems and associated auxiliaries.

Pametrada Research Station at Wallsend includes facilities for testing full-scale prototype machinery with powers up to 60,000 h.p. per shaft, and already four series of full-scale trials of high-powered steam turbine machinery have been completed. The value of these trials cannot be overestimated, since they not only enable faults to be eliminated before the machinery is installed, but also provide confirmation of design data and opportunities for research on full-scale equipment. Unique data, obtained during some of these trials regarding transient phenomena during astern operation, has recently been published (Ingram and Peile, 1951) and is well worth study. Research work on steam turbine blading, nozzles and diaphragms has enabled new and improved forms of these components to be incorporated in the designs prepared by the association for its member firms, and over 80 per cent of the machinery now under construction embodies these improvements.

It seems likely that one of the main developments of the future will be the use of higher temperature steam at the turbine inlet, and it is interesting to note that Pametrada have under construction an experimental turbine designed to operate at 1200 deg. Fah. and 1100 lb per square inch pressure.

Improvements in efficiency of marine steam turbine main propelling machinery are becoming more difficult to obtain, but auxiliary machinery has not been developed to the same extent and may well provide a fruitful field for research and investigation.

Gas Turbines.—The chief problems still requiring solution are:—

(1) The ability to burn oil of the same quality as used in the furnaces of vessels with steam turbine machinery. Fouling or corro-

* Director of Research, British Shipbuilding Research Association.

sion of turbine blading and heat exchanger surfaces by fuels containing vanadium and sodium salts is still a problem, and its successful solution may govern the degree to which gas turbines can replace existing forms of machinery for main propulsion, and how soon this can happen.

(2) Attainment of higher thermal efficiencies. At the present time gas turbines under development for marine propulsion utilise materials suitable for temperatures of 1200 deg. Fah. and have thermal efficiencies of the order of 30 per cent, corresponding figures for thermal efficiency of modern steam turbine and diesel machinery being about 25 and 38 per cent respectively. The possibilities of increasing gas turbine efficiency by higher inlet temperatures of the order of, say, 2200 deg. Fah. have been interesting many investigators, and this Institution recently had an authoritative paper (Brown, 1950a) on the subject, which is indicative of the present thought and research on this problem.

(3) Means of manœuvring. This problem, peculiar to marine application, arises because it is not practical to adopt the usual steam turbine solution of an astern turbine. Various solutions have been proposed, but only experience will show which is the best for marine conditions.

Water-tube Boilers.—To allow a more extensive study of combustion of furnace fuel oil, a specially designed forced circulation combustion test boiler, converted from a La Mont steam gunboat boiler, has been installed by the Admiralty. With this boiler a full-scale study can be made of the effects upon flame size and shape and combustion efficiency, of such factors as register design, draught loss, oil and air temperature, oil droplet size, air or air-steam atomisation of the oil, ratio of refractory to cooling surface, and mixing of flames for multiple registers; this boiler will also be used for the development and test of equipment for future designs of boilers.

Fig. 10 shows a general view of this boiler. Except for the front wall, on which any registers can be fitted, the furnace is completely water cooled; the back wall (shown in Fig. 11) is adjustable to give furnace lengths from 7ft 6in down to 3ft. The front, sides and back of the furnace are fitted with twelve observation holes, and any amount of furnace floor or walls can be covered with refractory as required. The boiler can accommodate burners up to 10,000 lb of oil per hour, and forced draught fans capable of supplying air for this quantity at 200in water gauge are being provided. The draught loss through the boiler and preheaters being only 20in, the larger part of the total pressure is available for register draught loss. Air preheat temperature can be varied by damper by-pass from atmospheric to nearly 600 deg. Fah., and the fuel pumps for this boiler will deliver up to 1500 lb per square inch.

The respective merits of forced and natural circulation for water-tube boilers has long been the subject of extensive study, but in the marine field natural circulation continues to more than hold its own. Nevertheless, we are still without a full understanding of the fundamental principles of natural circulation, and it is not unknown for new designs of boiler to require important modifications before satisfactory performance is obtained. A study of these matters in an actual multi-tube boiler presents considerable difficulty, as does also model testing, since there is a very pronounced scale effect which makes it almost impossible to simulate all the variables concerned.

Owing to this situation the British Shipbuilding Research Association decided some time ago to study the problem on a full-scale two-tube boiler, designed for a maximum working pressure of 1500 lb per square inch with a steam generation of 1200 lb per hour when operating with a tube of 2¼in outer diameter, heated length 10ft 6in and a heat input rate of 120,000 B.Th.U. per square foot per hour generated by a 250kVA electric furnace. Provision is made for altering the tube length, diameter and inclination, and also the heat input rate. Later it is proposed to go to higher rates of heat input with the aid of gas heating.

The plant may be operated as a simple closed system in which the steam generated is condensed in a condenser integral with the steam drum, the condensate refluxing back into the steam drum. Alternatively, it may be operated on the more orthodox system which comprises a hotwell, feed pump and feed heater. In this, the steam, after passing through the feed heater, enters the atmospheric condenser and flows through the measuring tank to the hotwell.

This boiler is now in operation and should provide valuable data regarding the effect of pressure and heat input upon circulation rates, together with the effect of such variables as tube diameter and inclination, and "downcomer" to "riser" area ratio. Data on heat transfer are being obtained, and it will also be possible to examine the effects of rapid pressure changes.

FIG. 10—*La Mont Boiler Installed at an Admiralty Experimental Station*

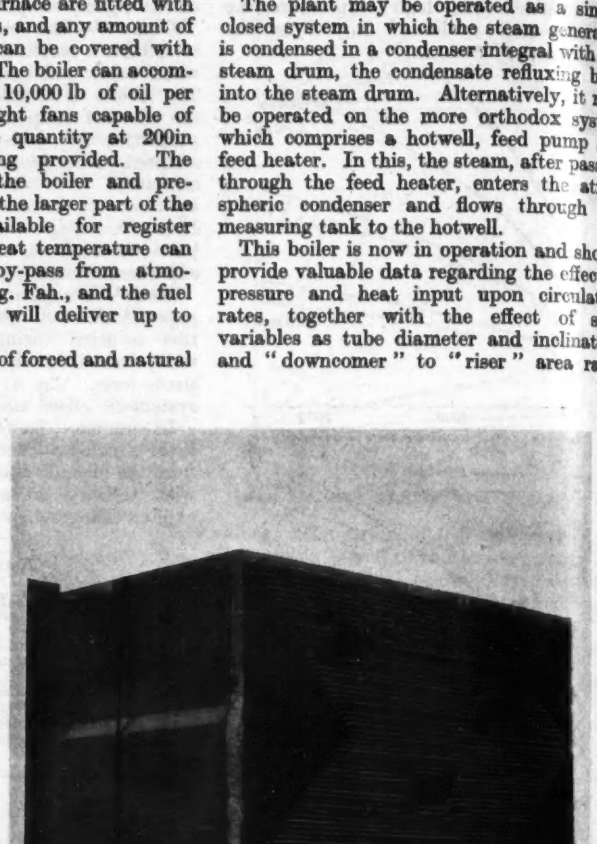


FIG. 11—*Back Wall of Boiler Illustrated in Fig.* 10

Diesel Engines.—One of the main developments with this type of engine since the 1939–45 war has been the increasing tendency to use heavy boiler oil as fuel in place of high-grade diesel fuel. It has long been known that many slow-speed marine oil engines are capable of operating with heavy boiler oils, and indeed over the last twenty-five years a number of ships have from time to time operated with such fuels. It is only since the war, however, that the difference in price between the two classes of fuel has been sufficient to encourage shipowners to use heavy oil, in spite of the increased capital investment needed for the provision of purifying equipment and the possibility of increased upkeep charges, especially for liner renewals. This development has received a notable impetus from research carried out in Great Britain by the Royal Dutch Shell group; it included experimental work ashore with a full-size single-cylinder

engine, followed by extensive sea trials on a number of different kinds of engine in the company's tanker fleet. So far attention has been concentrated upon the use of heavy oil in the main propelling machinery. Consideration is now being given to the problem of utilising the same fuel in diesel generators, as it is obviously disadvantageous to have to carry two grades of fuel. Owing to the trunk piston construction and higher rotational speeds employed in diesel generators, it has always been considered that the use of heavy oil would impose a more difficult problem than with main engines, but encouraging results are being reported from experiments both ashore and afloat.

As a result of a disastrous explosion in the engine-room of a quadruple-screw British passenger liner, much attention has been given in the last four years to the question of crankcase explosions, and research is being energetically pursued.

The problem logically calls for three stages of investigation. In the first place, the nature of the explosive medium must be established and the potential sources of ignition identified. In the second place, precise information is necessary regarding the conditions under which the explosive medium may be ignited and continue to react explosively, so that preventive measures can be devised. Finally, exact data must be obtained regarding means of limiting the effect of the explosion should it occur in spite of preventive steps. A systematic investigation on these lines is being carried out at the Imperial College of Science on behalf of the British Shipbuilding Research Association, and considerable progress has been made.

From analysis of the details of explosions which have occurred in various types of reciprocating engine, both diesel and steam, it is now generally accepted that they are caused primarily by overheating of some part of the engine, and that the lubricating oil and air in the enclosed crankcase forms the source of the explosive medium. The exact mechanism leading to the formation of an explosive oil and air mixture was not clear, however, until it was pointed out that lubricating oil coming into contact with an overheated part will condense, on mixing with the general crankcase atmosphere, to a fine mist, which will be liable to ignition by the same hot part that caused its formation. This suggestion, first advanced after work on explosion hazards in badly ventilated machine shops, fits in with the fact that just before many crankcase explosions white "smoke" has been observed. It is to be noted also that in such a condensed mist the oil is more finely divided than in the mechanical spray normally present and that it is therefore likely to be more readily ignited, to have a wider range of inflammable concentrations, and to burn more rapidly, thus giving rise to greater pressure effects in the closed crankcase. Condensed mist is therefore the "worst case" from the explosive viewpoint, and has therefore been used in most of the experimental work carried out for the British Shipbuilding Research Association.

After a thorough investigation of the combustion properties of condensed mists from typical lubricating oils, the relief of crankcase pressure has been investigated. Until recently the only guidance available on this aspect came from some American experiments (Reinertson and Crowley, 1948) and from experiments carried out in Great Britain by the British Internal Combustion Engine Research Association (Hoare and Conybeare, 1951). This problem unfortunately has a significant scale effect and, as both these sets of experiments were carried out with vessels considerably smaller than the crankcases of large marine oil engines, the results cannot be applied directly to the marine problem. This situation has recently been remedied by B.S.R.A. with a series of explosion experiments in a vessel of 200 cubic feet using condensed mists as the explosive medium.

Marine Gas Turbines and the Aeronautical Engineer

INSTITUTION OF MECHANICAL ENGINEERS

No. II—*(Concluded from page 185, February 1st)*

FURTHER abstracts from the discussion on Mr. A. Holmes Fletcher's paper on marine gas turbine design (Institution of Mechanical Engineers, January 25th) are reproduced herewith.

Mr. F. M. Owner said that he was the more pleased to endorse the author's advocacy of the merits of the free power turbine and heat exchanger in that he himself had been fortunate enough to be associated with the first aeronautical turbine to incorporate both features—the Bristol "Theseus" propeller turbine. In his opinion, however, the author did not sufficiently emphasise the merits of the heat exchanger turbine on part load, where the thermal ratio and therefore the fuel saving increased appreciably in comparison with the full-speed condition.

This was not equally so in the case of the high-compression engine without heat exchanger. The engine of 8/1 compression, he was sure, had a heat exchanger; and if the curve indicated heat exchanger engines, he would be interested to know whether the adoption of the intercooler had circumvented the common difficulty which prevented the utilisation of more than 5/1 compression ratio with a heat exchanger on anything above 50 per cent thermal ratio. The reason for that difficulty was, of course, the rapid approach of the compression temperature to the issue pipe temperature. To some extent, though not wholly, this would be reduced by the adoption of an intercooler—an expedient which, he was afraid, was hardly open to the aeronautical engineer.

As regards the free power turbine, the location between two compressor driving turbines would appear to make for instability, in that the removal of the load in the power turbine would increase the pressure drop across the low-pressure turbine, thus tending to decrease the delivery of the low-pressure compressor and therefore the speed of the engine as a whole. It would seem preferable to make the power turbine the last one of the group, and in practice this had been shown to possess very desirable stability.

He had on many occasions seen a Bristol propeller turbine started up with the propeller buzzing merrily backwards, and it had no ill effects on the engine. The propeller merely stopped and obediently started off in the right direction.

Mr. L. J. Cheshire stated that the phenomenal success of the jet engine was due, first, to the fact that it opened up a field which no other prime mover could enter, and once it could be developed successfully it could have no rivals in that field. This condition did not apply to industrial and marine applications.

It seemed to him that the author had not, in fact, considered the matter as an engineering problem, and it was a little difficult to see what objectives he had taken corresponding to those which were perfectly clear in the case of the aircraft gas turbine.

He referred to the kind of pressure loss factor, which the author was prepared to put up with and which drove him to expedients which were not yet established even in the aircraft field, so that the proposed lay-out, which might be excellent where low frontal area justified sacrifices in other directions, made unnecessary and inexcusable losses where space and weight were not over-riding limitations. Long-life plant need not be suitable for a fuselage in order to be compact.

He suggested that in many mechanical features aircraft practice was of the utmost value, but that in respect of lay-out it imposed a crippling handicap; for, in spite of the author's attempts to bring duct velocities down, these were still too high, and the surest way to reduce parasitic losses was to keep duct velocities down.

In his view the design objective for industrial and marine gas turbines should be that of producing plant with the same order of dependability as steam plant with turbine temperatures very close to present-day aircraft practice, while using a very small proportion of what were known as strategic materials; and he did not think those objectives could be obtained without being prepared to use some aircraft techniques to the full and at the same time being prepared to throw away some others.

Rigid adherence to the aircraft design methods retained also mechanical difficulties which need not be faced, such as those resulting from elaborate sheet metal work as stress-carrying parts.

As an example of the kind of advance which could be made by departing from aircraft principles, he cited that of the combustion system, where, in his view, the louvred type of combustion chamber initiated by the Shell Company, in which the flame tube was uniformly cooled in a controlled manner and in which the flame in the primary zone never touched the flame tube, was a better fundamental solution. Experience so far with this design indicated that this kind of combustion chamber would have a mechanically long and trouble-free life. This was in complete contrast to the aircraft flame tube, which, although eminently suited for its duties, represented a definitely inferior design for industrial purposes.

Mr. J. M. Kemper said that, while he agreed with the author's objections to the use of moving parts inside burners, he suggested that closing off the burner orifice mechanically, and then recirculating fuel, was a convenient method of preventing cracking or cooling off of fuel in the burner whilst enabling the entire fuel system to be brought up to full temperature before starting and permitting instant restarting after any interval. He suggested that the operating faults which the author mentioned in this scheme would yield to improved detail design.

The gradual opening of burner nozzles suggested by the author as a means of obtaining satisfactory atomisation over a wide

range of fuel flow, appeared to reintroduce those moving burner parts which the author had already condemned. In addition, such a scheme would make the matching of a set of burners for uniform delivery at all loads much more difficult. Fuel pressures could be reduced considerably, thus enabling centrifugal pumps to be used with greatly reduced susceptibility to erosion damage, both in the pump and in the nozzles.

The flame radiation trials in Holland had confirmed that the use of steam for atomisation sensibly lowered flame temperatures, particularly near the burner.

Rear-Admiral (E.) W. G. Cowland observed that his remarks on the marine gas turbine would be from the point of view of the marine engineer.

He confessed that on starting to read the paper he had been full of hostility; but his hostility had become less and less. There were listed in the paper seven points, all of which it would be agreed were vital, but he had noted two points which ought to be added to the seven listed in the paper.

The first was life. The marine engineer had a funny idea that his engines should last longer than his ship. The ship probably lasted twenty-five years (he was not talking about "flash" naval boats, but about the merchant ship or the heavy class of naval shipping), and the marine engineer always insisted on his machinery lasting longer than the hull.

The second point was reliability, ease of maintenance and overhaul. For several reasons he was doubtful whether the author's proposed design would be practical and suitable. For instance, there were ¼in diameter tubes in the coolers. But ships ran aground, they got into shoals of fish, and condensers got choked at sea. He would hate the thought of a ship being at sea with a choked condenser with ¼in tubes.

He felt that those two points were of extreme importance as regards the design. Probably most of those present who had flown in an aeroplane had been delayed at some time or another by engine defects in the aircraft, but he was prepared to bet that none of them had ever been delayed by machinery defects in a ship.

Lieut.-Commander (E.) P. T. Hoath said that he wished to take up two points in the paper. The first was intercooler design. The author mentioned the arguments of secondary surface versus the annular plain tube design, but it was worth while examining this question a little further. The details of the intercooler were not given, but he thought it must employ ¼in O.D. tubes. On this assumption a design had been roughed out. It would be seen that it required 2184 ¼in tubes. Having had personal experience of what happened to condensers in the Tropics with ⅜in tubes, he might be forgiven if he said that he regarded such a design with such a large number of small tubes with apprehension. He did not know of any tubes smaller than ⅜in being employed on any sea-water circulating system, and this was not for the engines of a major vessel. The usual minimum size was ⅜in. He was very much open to correction on this point.

The second point was the centrifugal versus axial controversy. In his comparison between the axial and centrifugal compressor, he felt that the author was less than fair to the axial compressor.

Mr. H. J. J. Redwood felt that the author's approach to the problem of the marine gas turbine was right in principle.

In all new developments it was essential to make the utmost use of existing experience and design knowledge, and at the present time this was largely concentrated in the aircraft industry.

Secondly, he believed that the best way to economise in the use of strategic materials was to aim for the highest possible specific output from them. That policy might involve replacement of parts from time to time, but in such a design as recommended in the paper the parts requiring replacement were small and a net saving of material should result. The parts should not be unduly expensive when the engines were made on a production basis.

In the choice of components, he questioned the selection of the centrifugal compressor in preference to the axial, despite the reasons quoted. It seemed to him fundamental that in the design of a long-life gas turbine employing temperatures of the order quoted in the paper, the highest possible component efficiencies should be aimed at. This would then permit of a reduced size of heat exchanger and/or the maximum use of cooling air to give the life required for a marine gas turbine, which it would be difficult to get anyway.

On the performance aspect, the 10 per cent gain in specific output achieved by increasing the pressure ratio from 8 to 12/1 might be of greater importance than the 1 per cent gain in thermal efficiency at full power in some applications. It would be of interest to know the effect on performance at low powers of increasing the pressure ratio and varying the ratio of l.p. and h.p. compressor work in the particular cycle chosen.

It seemed to him doubtful whether the suitability of any turbine component for a 10,000 hours' life could be assessed on the basis of creep alone. Vibrational stresses, distortion, thermal shock, disc stresses, local hot spots, bearing failures—any of these might contribute to failure. He felt that some time must elapse before such weaknesses could be eliminated from engines operating for long periods at high temperatures to the extent that only creep of the blade material remained as the criterion of life.

A reduction of 150 deg. Cent. in the temperature of the turbine blades by the use of air cooling was very acceptable, but was this reduction achieved evenly across the blade section and the trailing edge? If they also involved air cooling there might not be any gain from the use of the higher temperature.

Were ball and roller bearings requiring periodical replacements suggested, or did the author's calculations take into account the quite large frictional losses resulting from the use of plain bearings?

Naval Considerations

Commander (E.) G. F. A. Trewby said that to the Royal Navy, the main advantages which the gas turbine had to offer for main propulsion were: reduction in machinery weight and space for a given endurance, reliability, easy maintenance, rapid starting from cold, and great flexibility in operation.

Those important military qualities, inherent in the principle of the gas turbine, might never be realised if the design of naval gas turbines was based on principles established from long experience with steam. This did not imply that all aspects of aircraft engine design were suitable for naval gas turbines. The stresses and corrosion allowances must be modified for the longer life, reliability must be improved by introducing sleeve bearings in place of ball bearings; and if the turbine was to burn residual fuel, the multiple combustion cans should be replaced preferably by a single low-rated large combustion chamber. Another point was that the disposition of the cans around the turbine casing impeded access to the turbines.

The adoption of aircraft design techniques, however, brought disadvantages not mentioned by the author. In general, the cost per horsepower would be greater unless the units were mass produced, and the manufacture and inspection must be more rigidly controlled. The cooling air required for the high temperature took a heavy toll on performance, and the small turbine wheels could not extract the same quantity of heat from the gases as multi-stage turbines. Bearing this in mind, the consumption figures of 0·45 lb per horsepower-hour at 50 per cent power and 0·47 lb per horsepower-hour at the full power quoted in the paper appeared to be optimistic, and he had been interested to note that in presenting the paper the author had increased those estimates by 5 per cent.

He found it very surprising that the author, after having stressed the importance of symmetry, advocated the use of centrifugal compressors. For a 4000 h.p. marine gas turbine, as Lieut.-Commander Hoath had pointed out, it should be possible to design axial compressors with efficiencies at least 2 per cent higher than any centrifugal. The large increase in overall plant efficiency achieved must surely rule out the centrifugal compressor for this application, at any rate.

Combustion Chamber

Mr. P. Draper said that, with regard to the number of combustion chambers, it was just possible that where a cheap plant, without heat exchanger, was considered—which generally implied a distillate or gaseous fuel—there might sometimes be a case for the straight-through lay-out with multiple chambers. But where a heat exchanger was dictated on the score of fuel economy, there were definite advantages in the reduction of the number of chambers.

Apart from the inherently lower cost of manufacture, one avoided the difficulties of matching and controlling multiple burners, which would have to be manufactured to incredibly close tolerances or else be selected and matched in batches, as stated by the author. The single or larger combustion chamber avoided scantlings and metal thickness likely to give shorter life due to oxidation or distortion. On the debit side, larger chambers were rather more difficult to cool and the correct introduction of air to fuel was less easy. On balance, he concluded that "the fewer the better."

Mr. S. B. Bailey remarked that, in his own opinion, the case for the light gas turbine of comparatively short working life could be strengthened not a little by consideration of such simple factors as obsolescence and weight.

A marine steam turbine designed to-day was unlikely to be so obsolete twenty years hence that it would be economically worth while replacing it before then.

The same thing was not true of the gas turbine. It was but eleven years since Whittle's turbo-jet had first flown, and the gas turbine art was in much the same state of flux now as the steam turbine art had been in the year 1900. And with the gas turbine one was not tied to a boiler installation for one's working fluid. New blade materials could be incorporated as they became available, and with a free power turbine it should be possible to take advantage of them without necessarily replacing the compressor or the combustion chambers. Was not this rapid obsolescence itself a very good reason for preferring the lighter machine with its 10,000 hours' working life?

Before the war every pound of weight

saved had generally been considered to earn about £50 during the life of an aircraft. Since then more ingenious ways of making weight appear expensive had been devised, and by choosing the right combination of aircraft and route one could boost that figure up as high as £1000. Although one would not expect figures of anything like that magnitude outside the aircraft industry, he wondered whether the author had any information on the value which might be placed on the saving of weight and space in ships' machinery.

The chairman said that the author would reply to the discussion in writing.

Mr. A. Holmes Fletcher, in acknowledging the vote of thanks, said that he had, indeed, gathered from the discussion that the paper was provocative, as one of the contributors had mentioned. It had been intended to be provocative, and he thought that the discussion had been a very good one. It had, in fact, given him the impression that the 4000 h.p. design he suggested was a fine thing—if he could change the compressors, have a single combustion chamber, a different intercooler, a different heat exchanger, and so on!

Manchester-Sheffield-Wath Electrification

DUNFORD BRIDGE TO WATH

No. I

Electrified working of freight trains between Dunford Bridge and Wath began commercially on Monday, February 4th, marking the first stage in the Manchester-Sheffield-Wath electrification. The complete scheme, which envisages a considerable increase in the capacity of the line by hauling all classes of traffic electrically, was begun by the former L.N.E.R. in 1936. Because of the war construction was held up between 1939 and 1947. Operation is by two classes of locomotives, with 1500V d.c. overhead line equipment, and regenerative braking is provided for.

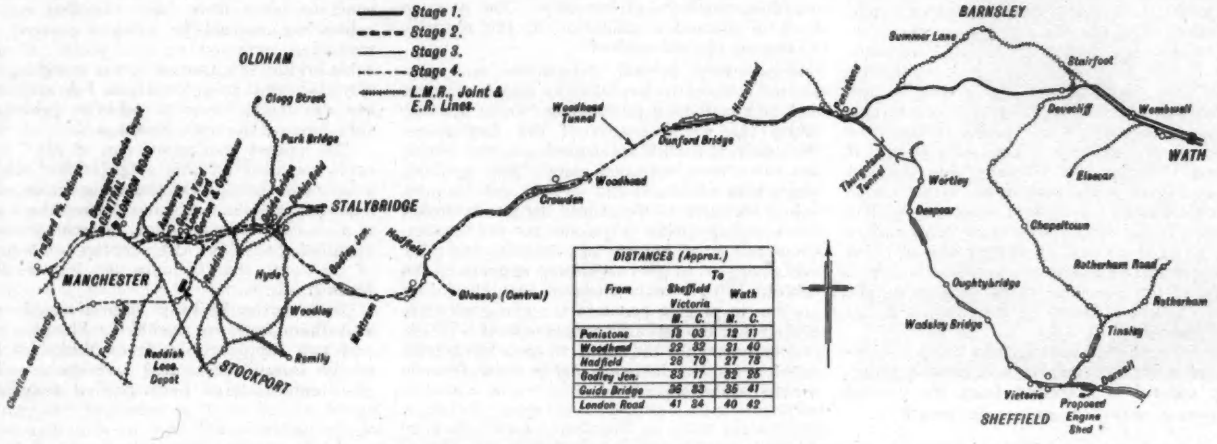
IN our issue of February 24, 1950 (pages 248–250) we gave an interim account of the progress then made with the Manchester-Sheffield-Wath electrification. Two weeks ago, at the invitation of the Railway Executive, Eastern Region, we were able to see something of the first stage of the scheme, between Wath and Dunford Bridge, just before the start of commercial operation of electrically hauled freight trains.

For the sake of completeness in the present article, we propose to recapitulate the main points of the scheme as described in our previous article.

It will be recalled that the complete electrification covers 75 route miles and a total of 350 miles of track. Details of the scheme as it stood two years ago are given in the map reproduced herewith, which is correct to-day as far as the first stage is concerned. The main changes, not shown on the map, are that stage 2 will consist only of the local Manchester-Glossop line, and that the scheme as it now stands will not include the section from Manchester Central to Reddish Depot. In referring to the map, therefore, attention should not be paid to the stages beyond the first, bearing in mind that the rest of the work is proceeding as rapidly as the supply of materials and labour permits. Power for the first stage of the scheme is supplied at 33kV from the Yorkshire Electricity Board's Aldham substation, whence it is transmitted by three-core 33kV cables routed along the tracks to railway substations at Aldham Junction, Stafford Crossing, Barnsley Junction and Dunford Bridge. In the completed scheme there will be two other supply points; one, at Sheffield, will be available in six months' time; the other, at Manchester, will be available when the Woodhead New Tunnel is completed.

An outline of the distribution system is given in the accompanying single-line diagram. Each of the substations contains e.h.t. outdoor switchgear for controlling the power supply between distribution feeders and busbars and between busbars and the outdoor step-down transformers associated with the rectifiers. A view of the outdoor substation at Barnsley is reproduced in one of our illustrations.

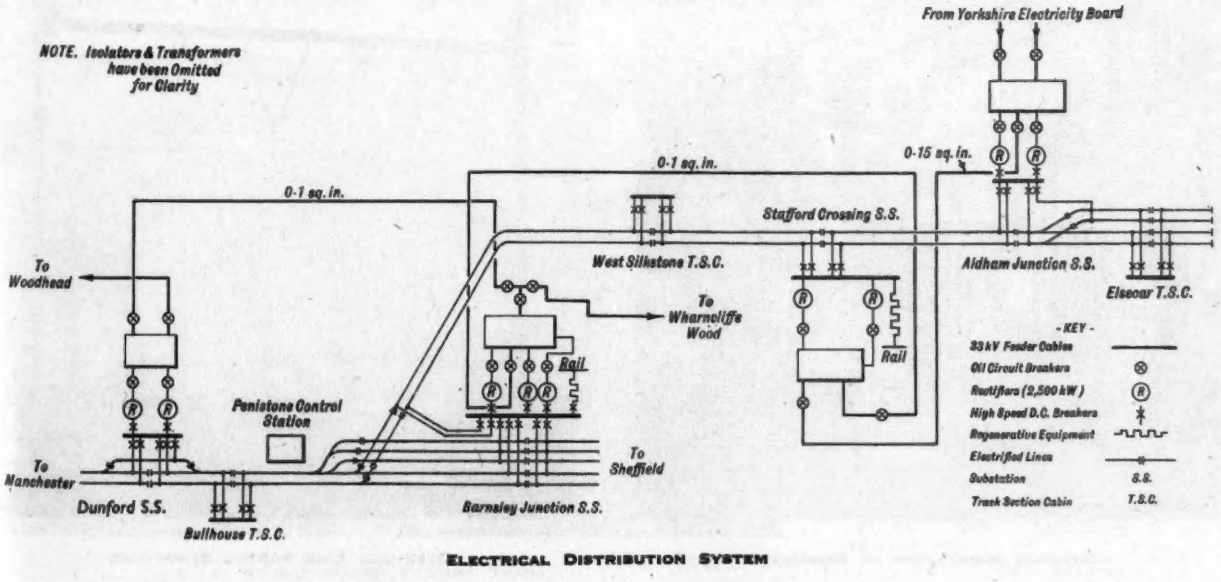
Pumped, steel tank mercury arc rectifiers are used for the conversion of the a.c. power to 1500V d.c. for the overhead conductor system. Three of the substations contain two twelve-anode rectifiers each, the fourth—Barnsley Junction—being equipped with three similar units. Each rectifier is rated at 2500kW



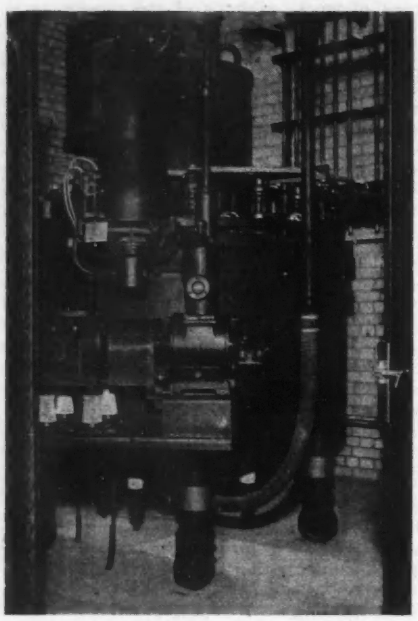
DISTANCES (Approx.)				
From	To Sheffield Victoria		To Wath	
	M.	C.	M.	C.
Penistone	18	03	12	11
Woodhead	22	32	21	40
Hadfield	28	70	27	78
Godley Jcn.	33	77	32	26
Guide Bridge	36	33	35	41
London Road	41	34	40	42

MANCHESTER - SHEFFIELD - WATH ELECTRIFICATION

NOTE: Stages 2, 3, and 4 have been amended as indicated in the text, column 3



ELECTRICAL DISTRIBUTION SYSTEM



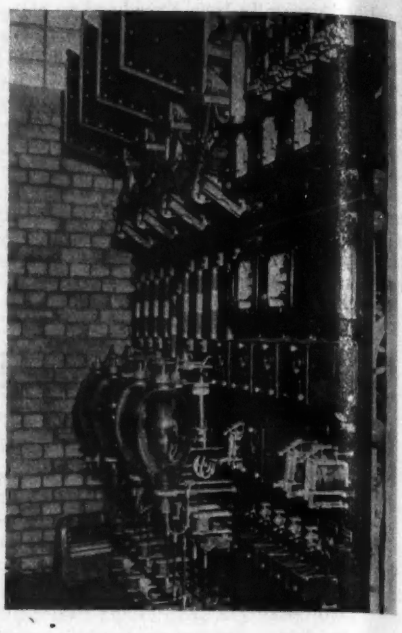
2500kW Mercury Arc Rectifier

and is capable of carrying overloads up to 10,000kW, the total installed capacity of this section of the line being 22,500kW. One of the rectifiers is illustrated herewith. The substations are equipped with control cubicles containing protective relays, local control switches and supervisory gear for remote control and with d.c. smoothing equipment and auxiliaries. The 1500V d.c. supply to the overhead lines is switched and protected by high-speed circuit breakers, and track sectioning cabins also containing high-speed circuit breakers are installed between most substations to limit voltage drops and enable faults to be cleared with certainty. The substations at Stafford Crossing and Barnsley Junction are also equipped with resistance banks (with electronic control) capable of absorbing 900kW of power from locomotives using regenerative braking, in the event of there being no load on the system to absorb the regenerated current. A view of the regenerative panel showing the ignitron tubes, at Barnsley Junction, is reproduced herewith.

Normally, the substations and track sectioning cabins are unattended and remote supervisory control is exercised from the control station at Penistone over pilot cables routed alongside the tracks. The control equipment, as illustrated, consists of an indicating master control panel which may be switched as required to any substation or track sectioning cabin for operational purposes to give indication of the position of the equipment therein. Remote metering of e.h.t. and d.c. busbar voltages and of rectifier output is also available at the control station.

Illumination of the control desk is provided by twenty 4ft, 40W "Osram" warm white lamps installed in sets of four above the five panels of a laylight, which is glazed with "Morocco" diffusing glass. Segments of white flashed opal glass are inserted in the panels to coincide with the ends of the lamps. The panels are hinged for access to the lamps and gear from below. The illumination on the desk is approximately 34 lumens per square foot, which provides good conditions for manipulation of the control keys and observation of meters. Lighting in the vertical plane for a mimic diagram of the supply system and track lay-out is also provided by the laylight. The illumination level on the panel is approximately 15 lumens per square foot, which is adequate for observation of the diagram and preserves contrast between the background and the indicator lamps showing the condition of switchgear at the substations. The general lighting is entirely indirect and is provided by thirty-four 4ft, 40W lamps in a continuous cornice, 122ft in length, round all four sides of the room. In order that the illumination may be continuous, the lamps are arranged with their ends overlapping. This arrangement, combined with the placing of the lamps at a slight angle to the direction of the cornice so that the centre of each is at the same distance from the wall, results in lighting with no perceptible variations of intensity. The average level of general illumination in the room is 15 lumens per square foot.

Supervisory control, telephones and protection circuits are provided by means of seven and four-star quad pilot cables, which are laid along the whole length of the first stage. Generally, the 33kV transmission cables (which are three core, screened, single lead covered, single wire armoured and served) and the pilot cables are carried on cast iron hangers mounted on concrete posts adjacent to the tracks. Creosoted wood battens are fitted to the pilot cable hangers to give additional support to the cables. Where obstructions are met, the cables are run in precast concrete troughing which is laid so that the lids are at surface level. Where it is necessary for the cables to cross the tracks, asbestos cement ducts are laid in concrete some 3ft 6in below sleeper level.

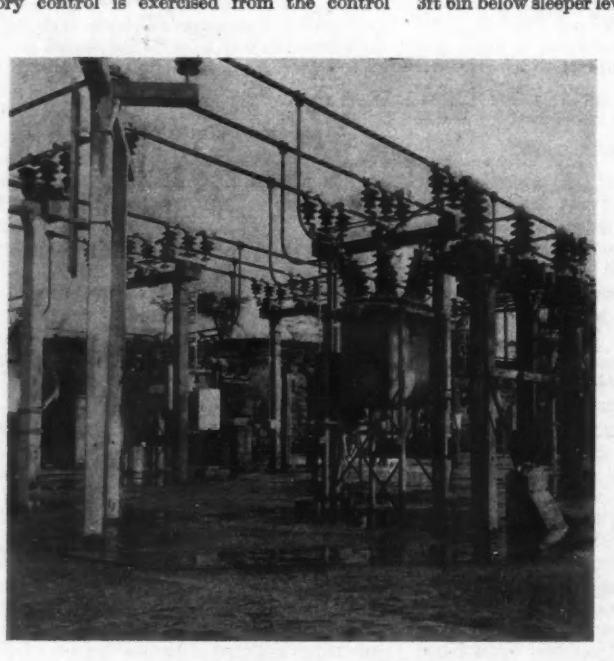


Regenerative Control Panel

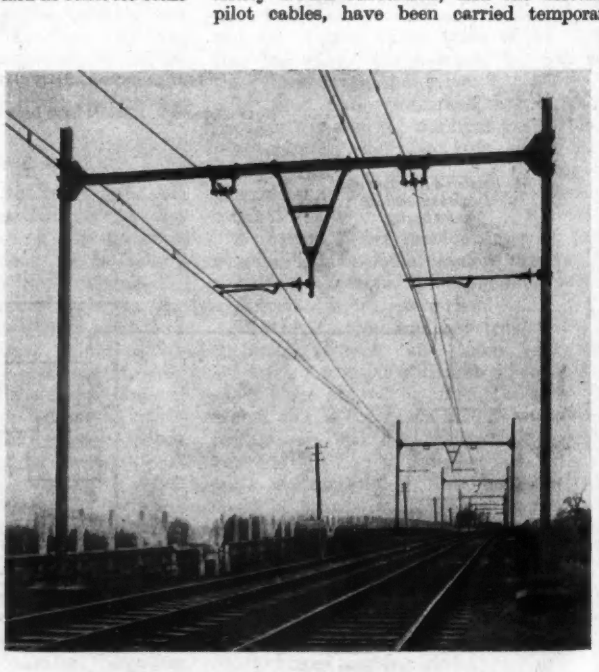
Between West Silkstone Junction and Wath the whole line is liable to subsidence caused by the underground mine workings, and special precautions had to be taken in installing the cable. In this area, as the result of observations made over a period of two years on an experimental cable route, special long reinforced concrete posts have been installed and the cables are carried in asbestos-covered steel troughing mounted on the posts. Concrete cable bridges are inserted in the troughing midway between post positions. Arrangements are also made for slack cable to provide for subsidence of the track crossings.

The longest continuous run of 33kV feeder cable installed on this stage is the 583-yard length laid through the Oxspring tunnel, where restricted clearance did not permit the making of a straight-through joint. Barrier joints are installed in the 33kV cable on the 2-mile section of the route that includes the 1 in 40 Wath Bank gradient.

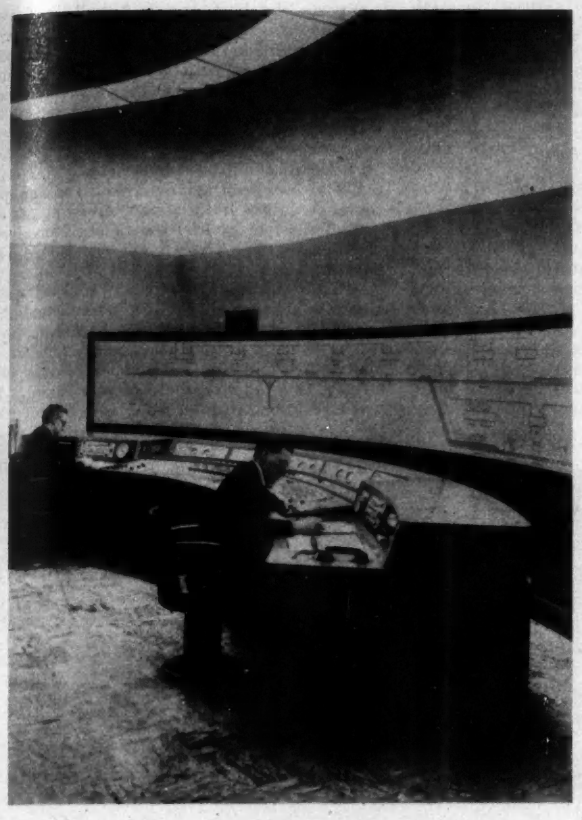
Close to the Railway Executive substation at Aldham Junction, the 33kV cables (one feeder and two supply cables from Yorkshire Electricity Board substation) and the associated pilot cables, have been carried temporarily



Outdoor Substation at Barnsley



Overhead Line Portal Structure



PENISTONE CONTROL ROOM

on double and single catenaries, pending the replacement of the existing bridge over the Dearne and Dove Canal.

Overhead Line Equipment

The overhead equipment is of compound catenary design, giving a total copper equivalent section of 0·75 square inch. It is intended to operate at a potential of 1500V direct current.

The major part of the route runs through areas where ground subsidence is liable to occur, due to colliery workings, and this situation presented many original problems to the designers. When subsidence occurs, the track is to be built up to maintain correct grading, and provision is made in the design of the structures to raise the overhead equipment, when necessary, to maintain the height of the conductor wire at 16ft above the track. All masts, bridges, and cross spans in the areas where subsidence might occur are adjustable, and the foundations and structures are designed to withstand the additional stresses that will occur when the equipment is raised.

Steel portals constructed from broad flange beams are used to support the equipment where there are less than four tracks. Lattice structures are generally used where there are more than four tracks, except in "subsidence" areas where the more easily adjusted cross-track catenary (head span) constructions are used. Some examples of the overhead structures may be observed in the accompanying illustrations. In the case of the portal frames, the bolts of the connection do not pass through the flanges of the beams; for the lattice head span tower foundations, the base channels are extended so that a jack can be used to plumb the tower after subsidence.

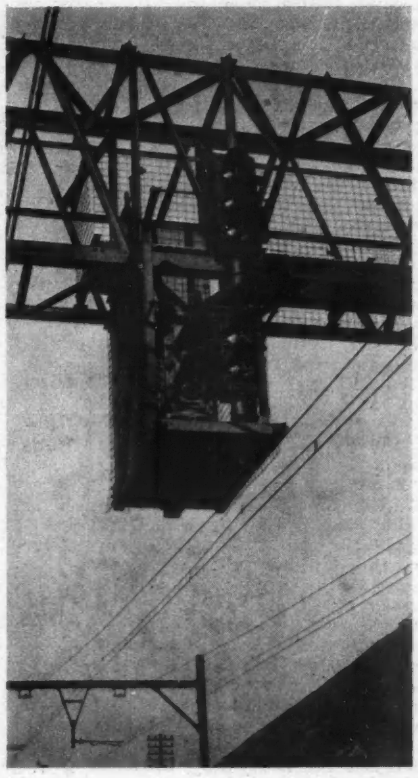
Signalling Works

The main alterations in the signalling in conjunction with the electrification of the line, which have been carried out by the Railway Executive's own labour forces, are: the conversion of the existing d.c. track circuits to a.c. type; the moving out of the distant signals on the main lines to give increased braking distances, and their conversion to colour-light type; various small resignalling schemes, and the cabling the overhead telegraph wires as necessary. All existing d.c. track circuits in the area have been converted to a.c. working and are condenser-fed circuits of double rail impedance bond or of single rail form as necessary.

All distant signals on the main lines have been converted to the colour-light system and moved out to give increased braking distance Where a distant signal was carried below a stop signal the stop signal has also been converted and the two combined in one colour-light signal. In some instances it has been necessary to carry the new signals on the traction overhead line equipment structures, which have been specially designed to carry them in cages suspended therefrom. Colour-light signals have also replaced the existing semaphore signals in certain cases where the overhead line equipment obstructed the view.

In connection with the provision of locomotive exchange facilities at Wath, Elsecar Junction and Wombwell Main Junction, new colour-light signals have been installed. Points situated beyond the mechanical working distance have been fitted with electrical point machines operating on 110V d.c.

At Wombwell Main Junction and Elsecar Junction the electrically operated points, together with the colour-light signals, are worked from small panels fixed over the centre portion of the mechanical lever frames and electrically interlocked therewith. A new ninety-lever mechanical frame has been installed at Barnsley Junction signalbox in connection with addititional locomotive facilities which have been provided. In the Penistone area it was necessary to convert a number of signals to colour-light signals in order to dispense with the semaphore signal gantries and brackets which prevented the traction catenary equipment from being erected. Throughout the area it has been necessary to make alterations to signalling equipment in order to make way for the overhead line structures.



DOWN-DIRECTING DISTANT SIGNAL

All the overhead open wire circuits have been cabled throughout the electrified area. Paper-insulated, lead-covered cable has been used and, in general, run on a stake route at the side of the track. Repeaters have been provided where necessary.

The new signalling and track circuits are supplied with power taken from the traction substations and distributed throughout the area at 660V, stepped down to 110V at the various signal locations, &c., as required. Standby power equipment has been provided at Aldham for the Wath area, to provide a signalling supply in the event of a serious fall in voltage or frequency of the incoming supply. The set consists of a 40 h.p. diesel engine directly coupled to an alternator, having an output of 25kVA, 415V, three-phase, 50 c/s. The normal supply from the traction substation is at 415V, three-phase, 50 c/s, and is transformed to 660V, single-phase, by 3/1 phase transformers.

DOUBLE-HEADED FREIGHT TRAIN

(To be continued)

Laminated Plastics

The West Chirton (Tynemouth) factory of Thomas De La Rue and Co., Ltd., opened in 1947, was specifically designed for plastic laminate production. Phenolic, urea- and melamine-formaldehyde resins are used with paper or fabric base. Stills and blending vessels are installed. The largest impregnating machine has a speed of 160ft per minute and amongst the presses is one of 5000 tons with 12 "daylights." Water at 250 lb per square inch and 150 deg. Cent. is used for process heating.

WE were recently invited by Thomas De La Rue and Co., Ltd. (Plastics Division), to visit its West Chirton factory at Tynemouth, an establishment specifically designed for the production of thermosetting plastic laminates. This modern building, which was opened in September, 1947, and now employs about 1000 people, covers an area of 50 acres and itself occupies 220,000 square feet. Its monthly production averages about 509 tons, in which is included a relatively small production of extruded plastics.

The quality of laminated plastics depends critically upon the rigid maintenance of temperatures, pressures, quantities, and processing times, amongst other factors, which occur in the production cycle, and the continuous production line which has been installed, aims to provide the best facilities for their closest supervision.

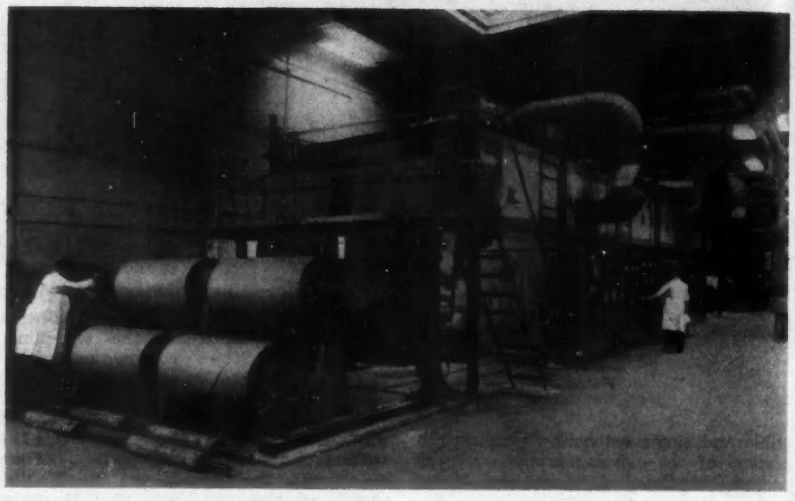
As is well known, the manufacture of laminated plastics consists of impregnating rolls, from amongst a considerable range of paper and woven fabrics, often in a phenolic or urea-formaldehyde resin; this material is then cut into sheets, formed into packs and subjected to heat and pressure simultaneously and is finally "cured" by cooling.

Products

The company manufactures three distinct laminated products under the trade names "Formica," "Delaron" and "Traffolyte." The range of "Delaron" laminates is one suited for many electrical and engineering applications and is made with either a paper or woven fabric base relatively heavily impregnated with a basically phenol or cresol formaldehyde resin. One electrical grade, for instance, using a paper base and ¼in thick, has a dielectric strength of 350 v.p.m. and an insulation resistance of 9×10^5 megohms, with an average tensile and shear strength of 9000 lb per square inch. Other grades available can withstand average stresses up to 20,000 lb per square inch. Grades using various quality cotton fabrics are designed for heavy-duty machined gearing, bearings and other stressed components and for low-tension electrical units. Its tensile properties improve with the number of threads per linear inch in both warp and weft direction of the fabric and with 110 threads per inch average stresses up to 15,500 lb per square inch in tension and 25,000 lb in shear are permissible.

"Formica" laminates are grades having invariably a paper base with the core sheets impregnated with a formalic resin. As it is used extensively for decorative horizontal and vertical panelled surfaces, a top sheet, suitably engraved, is impregnated in a melamine-formaldehyde resin, which gives the required translucent effect and provides a particularly hard non-porous surface.

A paper base with a urea-formaldehyde resin composes the laminates in the "Traffolyte" grades. This resin is softer and inferior to phenolic resins in most other respects, but being translucent, it is particularly suited for decorative purposes with plain colours and is cheaper.



HIGH SPEED HORIZONTAL IMPREGNATING MACHINE

The Production Line

A straightforward physical progression of material has been arranged from one shop to the next. Raw material is received at the east side of the factory and the finished product is dispatched at the western end with no doubling back during its progress.

A high-quality kraft paper is used extensively, this being almost 100 per cent cellulose. Important properties of this material, apart from its purity and homogeneity, are its absorbancy and wet strength, which, together largely determine the rate of processing. The woven fabrics include cotton and linen. Over two-thirds of the laminate production has a paper base.

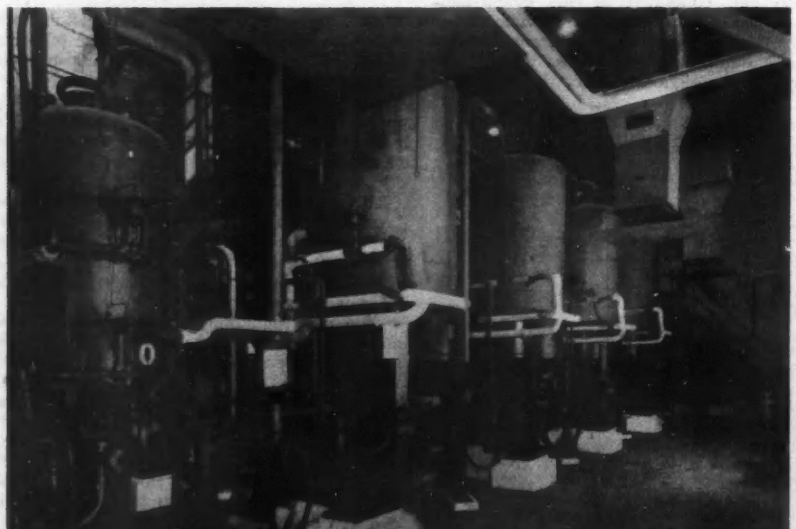
All materials are sampled and tested on delivery to the factory and no material is released for production unless it meets with the standards laid down by the laboratory.

Some resins are bought ready for use; others are blended in the varnish shop to the required specification and, in all, some sixty different grades of varnish are used.

In our first illustration can be seen some of the blending vessels in which the viscosity and specific gravity of the resins are adjusted before being piped to the impregnating machines or stored. Not shown in that illustration is one of the main 1000-gallon stills, in which the company prepares its own resins from the basic phenol or cresol and formaldehyde constituents. Because of their corrosive properties much of this installation is of stainless steel. The still is jacketed in order that the temperature of the reaction can be controlled by either cooling or heating.

The phenol or cresol, stored at a temperature of 60 deg. Cent., is piped to the still along with the formaldehyde and a condensing agent. For the proprietary blends the quantities, temperatures, processing times, and the catalysts used with the exception of ammonia, were not disclosed. Briefly, the constituents, being almost equal parts of phenol and formaldehyde with a very small percentage of a suitable catalyst, are stirred and allowed to reflux for a specific period, when distillation is commenced. This is allowed to proceed according to whether a liquid or solid resin is required. In the former case it is tapped off and taken to the blending vessels.

Pigment powders of the basic colours are prepared with a suitable base and stored in drums ready for the manufacture of the inks used in "Formica" grades. Printing is carried out on photogravure



VARNISH BLENDING DEPARTMENT

machines and by the substitution of various rollers the many designs which go to make up the range are produced.

Impregnation

Following the preparation of the primary materials, these pass directly to the impregnating shop. There are in all twenty-two impregnating machines with capacities and other characteristics suited to the production range. Of these installations, ten are arranged horizontally, the largest, by Mitchell and Co., being shown in our second illustration. It is over 100ft long and is shown handling two rolls of kraft paper, which are being each impregnated at the rate of 80ft per minute.

The phenolic resin is held in an aqua solution at a temperature of 21 deg. Cent. in a bath located at the front of the machine. After being drawn through the bath the paper passes between "percentage" or "doctor" rollers, which are so adjusted as to ensure the correct deposition of resin and a 100 per cent absorption. The particular production we saw on this machine forms the core of certain electrical grades, but is mostly used for the decorative laminates; it has a 35 per cent resin content. It will be realised that the speed of processing depends much upon the rate of absorbancy of the paper, its wet strength and to a lesser extent upon the varnish, and hence each machine has a large speed range and over the whole twenty-two installations a range of from 10ft to 80ft per minute for a single roll is provided. After impregnation the paper proceeds through the length of the drying oven, air heated at a temperature of 190 deg. Cent. down to 130 deg. Cent. at the exit. It is possible to evaporate all but 7 per cent of the solvent at this stage.

Parallel with this plant are four other horizontal impregnating machines, of smaller capacity, on one of which impregnation with urea-formaldehyde is carried out. Because of the fluid properties of this resin no doctor rollers are required. Amongst the other horizontal machines we saw one concerned with the decorative top sheet for the "Formica" grades using melamine-formaldehyde resin, where impregnation was also carried out without doctor rollers up to a 50 per cent absorption and at 12ft per minute.

Two of the four larger vertical installations are illustrated herewith, made by the General Engineering Company (Radcliffe), Ltd. With these machines the paper is taken vertically from the doctor rolls, proceeds to the top of the drying chamber, and returns to the varnish bath, where it can be passed through a second or third set of doctor rollers with the intermediate drying cycles, according to the amount of resin it is required to absorb. Paper impregnated on these machines takes up resin usually from 50 to 70 per cent of its final weight, and it is largely used for the electrical grades of the "Delaron" laminates. The core of these grades may also consist of the less heavily impregnated sheets processed on the large horizontal machine. All the machines are capable of working with the woven fabrics which are relatively heavily impregnated, the linen taking up to 60 per cent resin by weight.

Frequent tests are made on the paper while it is being processed to ensure that the treated material has the correct proportion of resin to paper and also that the resin has reached, but not passed, the state where it is fit for further processing. These tests, which are each completed in less than ten minutes, are of great importance in maintaining the standard of production.

The impregnated paper is subsequently transferred to high-speed cutting machines, some of which can handle four rolls at a time, where it is cut into one of six different sizes.

The Press Shop

The sheets are taken into the assembly bay, with the exception of the decorative surface sheets, which, having been subjected to both a printing and treating operation, are particularly valuable. These are stored in a special room to maintain their condition.

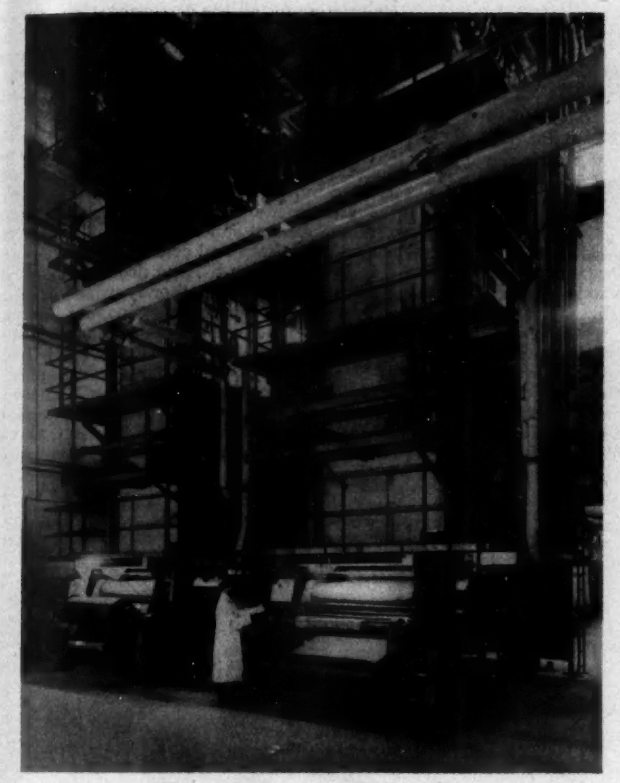
A given number of core sheets placed together and accurately lined up with a decorative sheet on top are put between mirror steel plates in "daylights" of several packs each. Each of these daylights, as it is completed, is inserted into place in the preloader in the case of the automatic presses. When the daylights are completed the press operator starts the automatic cycle. The preloader then slides the whole load into the press simultaneously, whereupon the upstroke press, working with eight rams, closes up. A pressure of approximately 1 ton per square inch is maintained for about an hour and a half, while the platens are heated to a temperature of 150 deg. Cent. This temperature is maintained for a specific period and then water cooled. The whole of this process is automatically controlled.

The press shop contains eight hydraulic presses, all of which can be seen in our illustration below, with the exception of the largest 5000-ton press, only part of which appears in that reproduction. This press and the one adjacent, of 4150 tons, both by John Shaw and Sons (Salford), Ltd., are similar in design and are fully automatic. Each has a working pressure of about 1 ton per square inch, the larger one having a platen 9ft by 4ft and twelve daylights, the other having only eight. The method of platen heating is of interest, as water under a pressure of 250 lb per square inch at 150 deg. Cent. is used.

In order to prevent fouling of the complicated pipe network in the platens a closed heating circuit is used, and almost the same water is perpetually circulated for the period of each "cure." Thus, during the heating cycle the pipe circuit is charged up with hot water from the main boiler-house and sealed, circulation being maintained by a separate pump. The temperature is maintained by a system of valves, which admit fresh hot water as required and allow for a compensating discharge. As soon as the requisite temperature is attained throughout the laminates this water is led to a heat exchanger and circulates in another closed circuit, where it is water cooled. This same water is then returned to the platens to act as a cooling agent.

Amongst the other presses working on the smaller packs, we noticed one dealing specifically with the laminates having a fabric base. Owing to the thicker finished slabs, which may be up to 5in thick, and composed of over 400 sheets, fewer daylights are practical and the machine is hand operated.

The boards, after being separated from the steel plates, are finally taken into the trimming shop, where the unpressed paper at the edges is trimmed off and the backs sanded to provide a



Vertical Impregnating Machines

The Press Bay

suitable gluing surface. All decorative boards ("Formica" and "Traffolyte") are pressed on mirror steel plates which impart a glossy finish. A matt finish can be produced if required. An aluminium foil placed close to the surface sheet is provided in some grades to prevent local burning. Later, the boards are passed on to the inspection department and sample strips from each load are sent to the laboratory for testing.

The laboratory is equipped with miniature stills and processing plant along with other research equipment and a range of mechanical testing equipment is installed.

Although the firm's main activity is concerned with plastic laminates, it has a number of machines working on extruded products. We noted four extruders using polythene, polyvinyl chloride, polystyrene and cellulose acetobutyrate respectively. In an adjoining shop the manufacture of decorative floor tiles is carried out, which are also made of polyvinyl chloride.

In all its activities the company has benefited particularly from the knowledge passed on by the American Formica Company, of Cincinnati, whose technical director, Mr. J. Cochran, was presented by President Truman in 1947 with the Hyatt Award for outstanding development work in the plastic field.

The Rome Metropolitan Railway

By C. CARTY, Dipl.-Ing.

No. I

Construction of the Rome Metropolitan Railway was suspended when the last war broke out. It has since been resumed. The line has a length of 11·332km, about one half underground, and runs south-west from Rome Central Station. The depth is shallow. Rail level varies between 8m and 11m below ground. But tunnelling methods have been used in its construction. The line is described, details are given of various structures, and references are made to difficulties encountered in carrying out the work.

THE history and development of the Rome Metropolitan Railway offers a striking example of the many difficulties and vicissitudes of a political and financial character which under present conditions interfere far more seriously than mere technical problems with the successful completion of major public works designed and contemplated before the outbreak of the last war.

The original purpose of the Rome Metropolitan Railway, the earthworks and formation of which have only been recently completed was to provide rapid means for mass transportation connecting the Rome Central (Termini) Station of the Italian State Railways with grounds about 7 miles south-west of Rome, Zone E.42 on Fig. 1, in which it was planned to hold an International Exhibition some time in 1942. However, the entry of Italy into the war made this latter project impossible, about 60 per cent of the works having been carried out by the time further construction of the Metropolitan Railway had to be suspended.

Activities were resumed in October, 1946, primarily in order to provide some measure of unemployment relief and as the largest possible number of local, chiefly unskilled, labour had to be employed, questions relating to actual traffic requirements, such as electrical and other equipment, including rolling stock, had to be left in abeyance for the time being.

No decision, for instance, has yet been taken on the signalling system to be adopted and although it has been noted that the newly opened Stockholm underground system is provided with continuous cab signalling, this is not considered suitable for the Rome Metropolitan Railway.

Motor coaches only will be used so as to make full use of any available adhesion. The tension of the two overhead copper contact wires of 100 square millimetres each, carried by a copper catenary of 120 square millimetres cross section will be 1500V d.c., the necessary current being supplied from four substations located respectively near the stations of S. Pietro in Vincolo, Circo Massimo, Garbatella and Magliana. With a maximum speed of 100km/h (62·5 m.p.h.) it is expected that the whole line will be covered in about fourteen minutes for the operating distance of 9·6km (say, 6 miles), including seven intermediate stops located at distances from each other varying between ½ mile and 1¼ miles. As each eight-car train will accommodate about 1600 passengers, the hourly capacity of the line with a normal time interval between trains of three minutes amounts to 32,000 passengers in both directions, and this can be doubled to 64,000 passengers per hour during peak periods by reducing the time interval down to ninety seconds.

The overall length of the line (Fig. 1) is 11·332km, subdivided in a city section underground about 3700m in length, followed by a surface length of 5100m with two tunnels of 490m total length, the line then running below the exhibition grounds for 1900m, after which it rises to the surface again for a distance of 600m, along which will be located the future installations for servicing the rolling stock. Of the total length, therefore, 6090m are underground and 5240m on surface. The minimum radius of curvature is 200m, 7700m being tangent and about 3600m being on curve. The actual operating length is 9550m. The main contractors for all the earthworks, &c., are the Societa Italiana per le Strade Ferrate del Mediterraneo, which operates many electric suburban railways radiating from large Italian towns, e.g., in Northern Italy the large Nord-Milan system around that city.

The Rome Metropolitan Railway has been designed and is being built under the direction of Sig. Dott.-Ing. Vito Perrone, ably assisted by the staff of a special department of the Italian Ministry of Transport entrusted with the general supervision of all works connected with the actual construction of the line.

It would appear that no decision has as yet been taken on the authority which shall be entrusted with operating the line, but it is anticipated that the concession will be granted to the Societa delle Tranvie e Ferrovie Elettriche di Roma, known as "Stefer," which already operates various lines connecting Rome with its outer suburbs and with places of interest to tourists, such as the Castelli Romani, as well as the Rome-Lido (Ostia) Railway, which

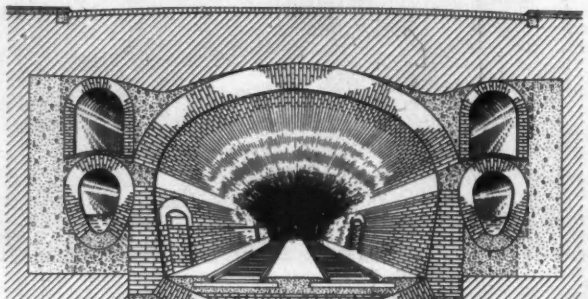


FIG. 2—SECTION THROUGH COMPLETED TUNNEL

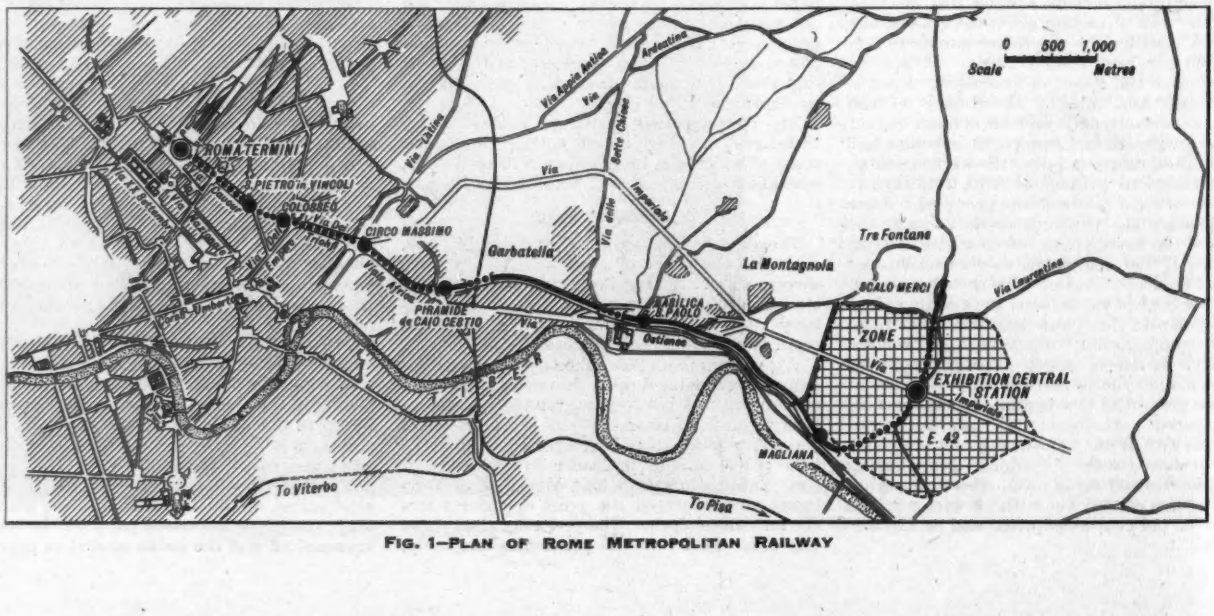


FIG. 1—PLAN OF ROME METROPOLITAN RAILWAY

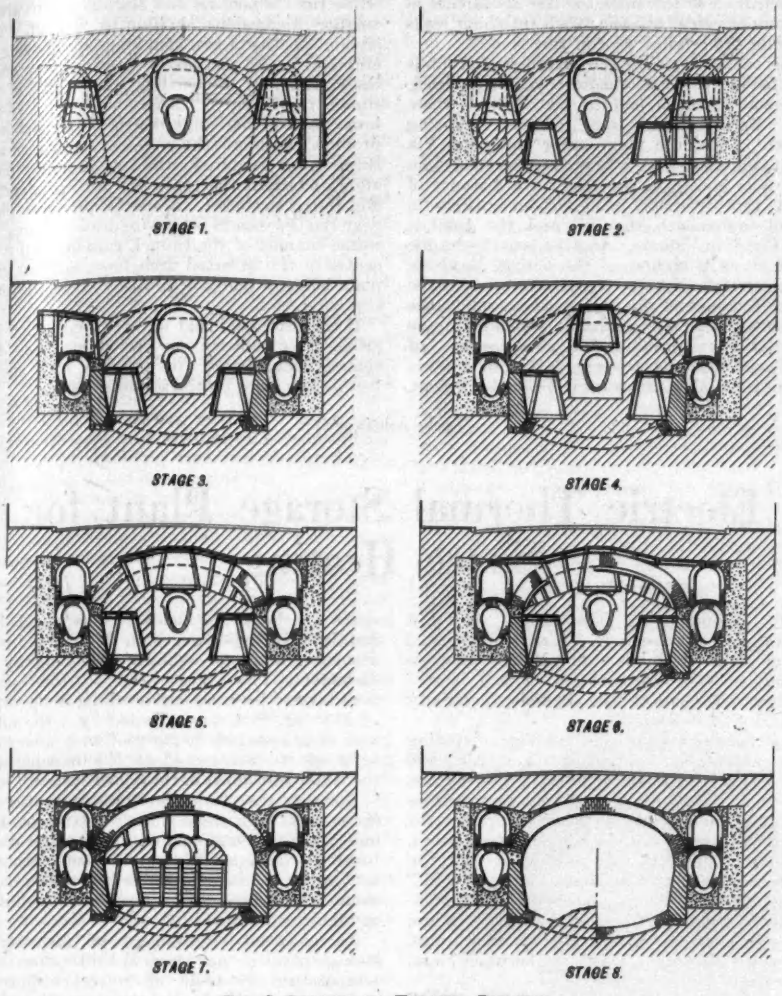


FIG. 3—STAGES IN TUNNEL DRIVING

runs parallel to the surface length of the Metropolitan Railway, as described below.

DESCRIPTION OF THE METROPOLITAN LINE

Starting a slight distance from the new Rome Termini main line station, the Metropolitan line first follows the Via Vicenza, then passes the first station, also called Termini, which is underneath the large new square in front of the main line station.

The Metropolitan line Termini station is at 46·13m a.D. The line then follows the Via Cavour until its intersection with the Via Giovanni Lanza. On this section, on account of the drop in surface levels, the Metropolitan line falls throughout with gradients comprised between 1·6 and 3·5 per cent. Because of the many difficult features of the subsoil of the Via Cavour described below, it was necessary to maintain the formation of the line at a fairly high level, so that the station provided at the intersection of the Via Cavour with the Via Giovanni Lanza had to be located on a 1·2 per cent downgrade. This second station is called S. Pietro in Vincolo, after the basilica housing the famous Moses statue of Michelangelo. Leaving this basilica and the Esquiline hill on the left, the line falls with a gradient of 3 per cent as far as the next station, Colosseo, which has been located on a 1 per cent downgrade.

After leaving this station the line falls with a gradient of 1·8 per cent down to 12·43m a.D., and in order to negotiate the restricted space available between the Colosseum on the left and the Arch of Constantine on the right, there is a sharp "S" curve at this point. The line then follows the Via San Gregorio with light gradients until it reaches the Circo Massimo station, which has been established with a gradient of only 0·06 per cent, following a curve of 200m radius. Following the Viale Aventino and the Via della Piramido, the line leaves Porta San Paolo in the ancient wall of Marcus Aurelius on its right and comes to the surface in the station of Piramide de Caio Cestio. This station is alongside the existing Porta San Paolo terminus of the Rome-Lido (Ostia) electric surface railway of the "Stefer" company, but as the Metropolitan line is only 7·10m a.D., there is a difference of 5m between the track levels of the stations, stairs connecting the platforms.

After this station and a tunnel under the forecourt and the tracks of the new Ostian station of the Italian State Railways, the Metropolitan line rises on a gradient of 1·2 per cent until it reaches the level of the Rome-Lido Railway alongside the Rome General Market at the Garbatella station of that railway.

Between this station and that of Magliana, the Metropolitan line runs alongside the Rome-Lido Railway on gradients not exceeding 0·8 per cent, being on the surface with the exception of a short tunnel underneath the Rock of Saint Paul prior to reaching the station of Basilica di San Paolo which, in addition to the renowned basilica, will serve the growing population of the Grottaperfetta district.

Leaving the Rome-Lido Railway, the Metropolitan line turns left at the station of Magliana, crosses the former Exhibition ground, "Zone E.42" and, after passing through the duplicated end station, it rises with a short 1·2 per cent gradient to the surface, terminating in a freight yard located at 18·50m a.D. The rolling stock depot has been provided at Magliana, together with the necessary repair shops.

STRUCTURAL FEATURES

The average depth between street level and top of rail is fairly shallow and varies between 8m and 11m, so as to remain above ground water level, which extends from 11m down to 18m below the streets. While this shallow depth of the line reduces the necessity for costly and complicated foundations to secure the buildings adjoining the tracks, it aggravated the difficulties connected with maintaining public utilities and other services in full working order while construction was in progress. This will be easily appreciated when it is realised that in some places the depth available between the extrados of the tunnel vault and the surface level does not exceed 0·6m to 1·5m.

It should be noted in this connection that, notwithstanding this shallow depth, most of the work below ground level has been carried out by the usual tunnelling methods, while facing conditions as described below.

On underground tangent sections the width of the tunnel at rail level is 8m, as compared with 8·165m for the standard gauge double track tunnel cross section of the Italian State Railways. On curves or in the vicinity of stations the width rises to 8·16m up to 8·80m.

The base of the tunnel rests throughout on an inverted arch; in sections covered with a segmental arch the height from rail level to intrados of arch varies from 5·5m to 6m. Where reinforced concrete beams had to be used this height varies from 5m to 5·30m, the minimum height between rail level and overhead contact wire being fixed at 4·65m for a maximum height of the motor-coaches with folded current collectors of 4·25m.

The tunnel cross section along the Via Cavour is a three-centre segmental arch, Fig. 2, flanked on either side by retaining walls and by walls underpinning the fabric of adjoining buildings down to a suitable low level alongside the retaining walls. These walls had to be built in small sections so as not to upset the existing equilibrium, which is

FIG. 4—TUNNELLING BELOW VIALE AVENTINO

very unstable because of the presence of ancient buildings and foundations down to a depth of 14m, of refills for which clay and tuffstone had been used in the past, of water-bearing strata, of ancient Roman galleries, and of a chapel dedicated to Saint Lawrence, all of which impeded the progress of the main heading and the existing structures had to be suitably consolidated and reinforced where necessary. Advance headings had to be driven in all the principal directions in order to explore the ground and to avoid the sudden collapse of some ancient vault, which would have endangered the main tunnel work in progress.

The buildings on the left of the line, being generally provided with continuous and strong foundations, gave comparatively little trouble, but those on the right were built on vaults carried on very deep pillars, which reach down to the level of ancient Roman structures. Hence the necessity, as stated above, for underpinning them by new foundation walls of a continuous character; the fills and some of these retaining and foundation walls had, however, to be carried out in situ within the water-bearing strata, as any lowering of the ground water level might have endangered the stability of the surface structures.

On this section special conduits for the public utilities and services have been provided between the abutments of the main tunnel and the retaining walls, together with new sewers at a lower level, as shown in Fig. 2.

Figs. 3, shows the different stages of the tunnel construction in Via Cavour. Between the Via Cavour and the Square of S. Pietro in Vincolo a maze of caves and ancient cellars was encountered. Some have been refilled with ballast set in mortar, while the largest have been reinforced with retaining walls supporting the vaults. Three shafts were driven down in this section, one 30m deep and two subsidiary shafts 22m and 19m deep.

The Esquiline hill consists of a thick layer of compact tuff, which rests on a compact bed of non-swelling, sandy clay with a limited quantity of ground water. As the rail level under this hill is 25m below the surface, this section was used as an air raid shelter during the war and additional entrances and exits were provided for the purpose, while the brickwork was rendered over the necessary distance instead of being left raw, as is generally the case on the remainder of the line.

The same cross section as for the tunnel under the Via Cavour has also been used beneath the Colosseum Square and beyond. Here sand formations were encountered, which called for special measures to avoid any settlement of adjacent buildings, while the tunnel was in the course of construction.

Under the square adjoining the Circus Maximus and the one facing the Rome-Lido line station, the very low building height available at these points made it quite impossible to use a vaulted brick structure, so that a reinforced concrete beam and slab roof had to be provided instead, over a total distance of 200m. In the section beneath the Viale Aventina, built by tunnelling methods large caves were encountered—the remains of old puzzolane earth quarries; the size of these caves may be gauged from the fact that the spoils were removed in horse-drawn carts. The pillars left standing by the former quarrymen to support the roofs of these caves are in many cases quite inadequate in cross section for the spans they support; moreover, in the time which has elapsed since quarrying was abandoned, the erection of many buildings and structures has still further aggravated the poor stability of these caves. Here, again, it was necessary to proceed with utmost caution and to drive exploratory headings in advance of the main tunnel heading and to support the roof with heavy supporting walls, after which the existing pillars could be demolished and progress of the main heading resumed. How these difficulties were overcome is visible on Fig. 4. In the foreground is the finished section of the tunnel vault; further back will be noticed one of the standing pillars bored through for the advance heading, opening at the centre; at the sides are the abutments of the tunnel vault, together with retaining walls carrying the original roof of the cave.

The tunnel beneath the Exhibition grounds is roofed in with a mass concrete segmental arch.

Special methods had to be adopted where the Metropolitan line crosses existing sewers. Thus, the main sewer along the Via degli Annibaldi with a cross section of 3·75m by 2·50m had to be diverted for a distance of 450m, this diversion being driven entirely in tunnel underneath the hill and the basilica of S. Pietro in Vincolo. Another large hydraulic structure is a siphon in the Circus Maximus square, which connects the main sewers of the Porta Metronia, of the Colosseum as well as the Clementina and Mariani drains, which had to be diverted as required. The cross section of the Porta Metronia sewer is 3·20m by 2·20m, that of the Colosseum sewer is 3·60m by 2·90m, while the Clementina and Mariani drains are of smaller dimensions, 1·40m by 0·90m. The siphon consists of two 35m long pipes having an elliptical cross section of 3·00m by 2·40m; the capacity of the settling tank ahead of the siphon is 370 cubic metres, while that of the lower tank is 200 cubic metres. The siphon is provided with all the necessary gratings and sluice gates required, while a pumping plant allows to drain the pipes dry for maintenance and repair purposes. A special pumping plant near the Colosseum is also used for draining the water channel of the tunnel, running along the centre of the inverted arch base, another such plant being provided in addition at the Piramide surface station.

It is anticipated that natural ventilation will prove quite sufficient so that it has been considered unnecessary to provide any special ventilating plant for the tunnel section.

(To be continued)

Electric Thermal Storage Plant for Space Heating

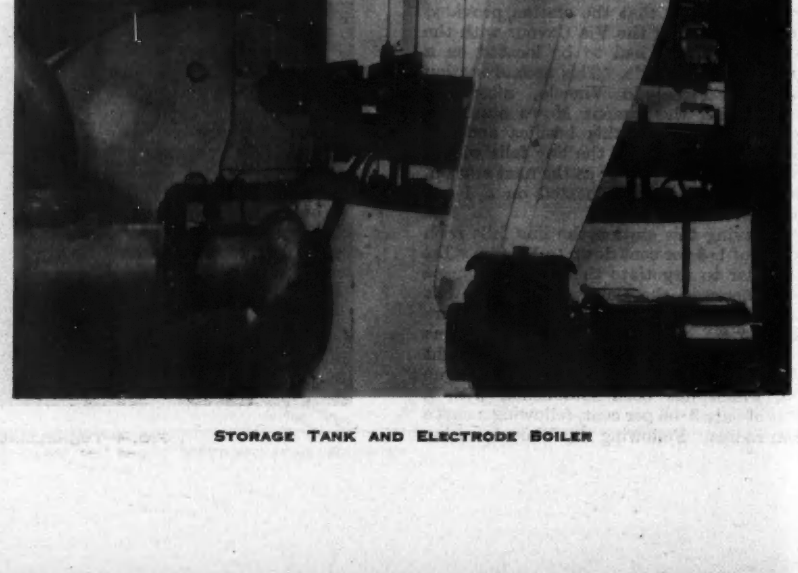
THE accompanying illustration shows a view of an electrode boiler and thermal storage plant which has been installed for space heating in the headquarters of the North-Western Division of the British Electricity Authority at Didsbury.

The thermal load of the buildings, including future extensions, was estimated at 2,000,000 B.Th.U. per hour when the internal temperature is 65 deg. Fah. with an external temperature of 32 deg. Fah. The hours of occupancy for the various buildings were taken between 9 a.m. and 5 p.m., and it was considered that the structure should not be allowed to go "cold" during the night hours. Accordingly, a circulation corresponding to one-third of maximum load was allowed between 5 p.m. and 7 a.m. with a two-hour preheating boost between 7 a.m. and 9 a.m.

The main plant consists of an 800kW "Autolec" high-tension electrode water heater manufactured by G.W.B. Electric Furnaces, Ltd., Dibdale Works, Dudley. The necessary storage vessels, pumps, mixing valves, &c., were designed and installed by G. N. Haden and Sons, Ltd., of Manchester. The storage temperature of the water is 230 deg. Fah., and the required storage capacity after allowance had been made for the heat loss from the cylinders and the expansion of their contents was estimated at 32,000 gallons. To suit the available space in the boiler-house it was decided to install three cylinders, each 33ft long by 7ft diameter, and one cylinder 27ft long by 7ft diameter. The static head to the system necessary to permit a safe working temperature of 230 deg. Fah. was afforded by a secondary feed tank installed in the roof with a capacity sufficient to accommodate the expansion of the water contained in the whole system.

Between the "Autolec" water heater and the storage tank there is a circulating pump, a high-velocity centrifugal unit with water-cooled bearings, designed to provide sufficient flow within the "Autolec" water heater to prevent steam formation on the electrodes when working at high temperatures.

An essential requirement of the thermal storage plant is that there should be an even temperature gradient of water within the storage vessels. An automatic mixing valve is therefore installed on the primary side of the circuit before the circulating pump. In each cylinder there are three thermostat pockets—situated at the top, centre and the bottom. Since the temperature within the vessels is built up in layers, from the top downwards, then by inserting the controlling thermostat in any one of these pockets, the electrode boiler can be closed down after any predetermined level of storage within these limits has been attained. It follows that, in very mild weather,



STORAGE TANK AND ELECTRODE BOILER

when the total heat content of the tanks is not required, the thermostats can be arranged to provide either one-third or two-thirds of the maximum heat storage. These thermostats are connected in the electrical circuit in such a way that the boiler closes down after the selected charging level has been reached.

On the secondary or distributing side of the storage vessels there is a normal low-pressure heating scheme, and provision is also made for a supply of domestic hot water, the flow and return design temperatures for the heating system being 180 deg. and 150 deg. Fah. respectively. A further mixing valve is installed in the secondary flow main, the mixing valve being controlled by an immersion thermostat installed in the secondary flow following the mixing valve. This thermostat operates in conjunction with an outside temperature controller by means of a pilot acting through a calibrator box, so that the flow temperature of the heating circuits is determined by the external temperature and the temperature in the building remains steady, despite fluctuations in outside conditions.

A time switch is included in the secondary system mixing valve circuit to switch over the heating system to night-time temperature operation, when the temperature is maintained throughout the building at a value of some 10 deg. Fah. less than the day-time temperature. At this reduced night temperature the mixing valve is controlled as before by outside temperature conditions.

In this particular building the client specified that the heating surface should be provided by radiators. The domestic hot water supply is provided by a calorifier which is served from the heating mains from the storage plant during the winter time, and by electrical immersion heaters for summer time operation when the heating system is, of course, closed down. Both the primary and secondary circuits have standby duplicate circulating pumps connected in parallel. To reduce heat loss from the tanks and pipework in the plant room, all surfaces are covered with 3in thick, 85 per cent magnesium slabs set in plastic finish.

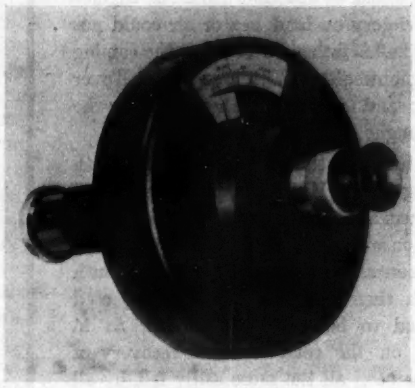
The electrode boiler is a "G.W.B." high-tension water heater made to operate on a 6·6kV, three-phase, 50 c/s supply direct on to the electrodes, and rated at 800kW. All control gear, motors, &c., operate on the normal 415V, three-phase mains. The unit is automatic in the sense that its output varies in accordance with the demand, and it is equipped with automatic temperature control whereby the working temperature can be selected at a master thermostat, the flow temperature being maintained to within a few degrees of the selected figure. Both temperature and rating controls operate by the movement of high-tension porcelain shrouds over the electrodes; the actual movement of the shrouds is done by a central driving shaft through the top of the boiler, operated by a small geared electric motor with a slipping clutch and electric brake, the whole drive unit being enclosed.

Inside the boiler the only moving parts are the porcelain shrouds which are made from high-density porcelain and tested to 1200 lb per square inch. The use of jets and variable baffles in the base of the boiler has provided sufficient velocity from the basic primary circulation to prevent steaming, &c., on the electrode surfaces, and the need for an internal circulating pump has been eliminated. The whole boiler equipment, including the l.t. control panel, is fully interlocked and the safety devices include phase failure, protection overload, no-volt and h.t. interlocks which prevent high-tension supplies being switched on until all parts of the system are in operation and l.t. supply is available. The equipment also includes protection by altitude gauges against any pressure change in the system, such as the lowering of pressure due to water loss or increase of pressure due to steaming. The whole equipment is controlled by a master time switch which, amongst other duties, ensures that primary pumps are in operation some fifteen minutes before h.t. becomes available to the boiler. This time switch also controls the whole sequence of the thermal storage plant operation, manual control being eliminated. Excess temperature thermostats are fitted to all tanks and to the electrode boiler itself, to ensure that the h.t. supply is switched off at the main switch if a dangerously high temperature should be reached.

Disappearing Filament Optical Pyrometer

Our illustration shows the disappearing filament optical pyrometer manufactured by Tinsley (Industrial Instruments), Ltd., North Circular Road, West Twyford, London, N.W.10. This pyrometer is a direct reading instrument which uses a null-balance bridge to give quick, accurate measurement of the temperature of bodies emitting visible radiation. The instrument was designed by the National Physical Laboratory in conjunction with the British Iron and Steel Research Association, and has been developed as a commercial instrument by the manufacturers.

Measurement is made by balancing the brightness of the object whose temperature is to be measured with that of a comparison filament. Balance is indicated by disappearance of the filament image, and in this condition a balanced bridge circuit measures the resistance of the comparison filament and, hence, indicates its brightness temperature with great accuracy. The bridge current rheostat and potentiometer



DISAPPEARING FILAMENT OPTICAL PYROMETER

balancing arm are adjusted by a single knob. Interlocking keys are provided to prevent accidental overloading of the galvanometer. There are two temperature ranges, namely, 800 deg. to 1250 deg. Cent. and 1100 deg. to 1900 deg. Cent.

The optical system comprises a simple telescope with the proper entrance and exit angles to ensure a bright field and good disappearance of the filament when a brightness match is made. A neutral filter is inserted in the optical system when the higher of the two ranges is required. Monochromatic vision is provided by a carefully selected colour filter. The lamp has a flat tungsten filament of very small thermal inertia and of sufficient length to eliminate ambient temperature errors resulting from end effects.

As illustrated herewith the pyrometer is self-contained except for a small portable battery which can be carried in a pocket. Light alloy with an anodised black finish is used for the body and the instrument proper weighs 2½ lb. The front extension tube, which supports the objective lens, provides a comfortable handle and the battery switch is arranged so that it can be operated by the gripping hand, with the minimum of movement.

We learn that the pyrometers are normally calibrated against a N.P.L. sub-standard filament, a certificate of calibration showing the corrections being provided with each instrument. If required, a N.P.L. certificate of calibration can be issued. The maker states that the comparison lamp in a pyrometer can be replaced without recalibration.

Engine Starter

The Berger "Handraulic" engine starter, which was described in The Engineer, July 14th issue, 1950, page 45, and at that time was being made in this country by Bryce Fuel Injection, Ltd., is now being manufactured by Berger Equipment, Ltd., Cardiff. This newly formed company has the sole manufacturing rights outside the Continent, and the present production is about 100 starters a week. A detail which distinguishes the working cycle of this starter unit is the use of a common medium for the storage of potential energy and the kinetic dissipation thereof in the starter; this medium, operating as it does in a closed circuit, is, therefore, non-consumable. The starter embodies a hydraulic accumulator which contains a sealed synthetic rubber capsule filled with air at 2000 lb per square inch, and normally occupies the whole of the accumulator. When required for starting, hydraulic fluid is pumped into the accumulator by a hand plunger pump compressing the capsule until both the fluid and the air pressure together attain a value of 4000 lb per square inch. Hydraulic fluid is then available during the expansion of the air from a pressure of 4000 lb per square inch, dropping to the final pressure of 2000 lb per square inch, when the air again occupies the accumulator volume. The fluid is admitted to two opposed helical gear racks working on a single pinion directly connected to the engine crankshaft, these three being the only moving parts.

Safety in Mines

The twenty-eighth annual report on *Safety in Mines Research*, which has been published this week, deals with the work carried out, during 1949, by the Ministry of Fuel and Power under the direction of Dr. A. H. A. Wynn. It reviews progress made with investigations made into fire and explosion hazards, dust control and pneumoconiosis hazards, and also includes some account of the engineering and metallurgical research work accomplished by the Directorate. In the latter field, the report notes, the resources of the laboratories were very limited, though before the end of 1949 plans were being discussed for transferring the work on mine supports and wire ropes from London to Sheffield, where the metallurgical work is established. During the year reviewed investigations continued into the causes of premature failure or deterioration of wire ropes, and 126 rope samples from light-duty winding ropes were examined on behalf of the Chief Inspector of Mines in connection with applications for extension of rope life. This work, which has continued since 1937, has stressed the importance of corrosion as a cause of rope deterioration and the value of metal finishes in improving rope life. The metallurgical examination of mining gear, the report states, again showed the importance of testing the quality of materials supplied to the mining industry, material supplied being sometimes quite different from, and of poorer quality than, the material ordered. In the Buxton laboratories, the haulage section has concluded a study of mine locomotives. The same section has continued investigations on the carbon monoxide and oxides of nitrogen in the exhaust gases from diesel engines. The results showed that the concentration of oxides of nitrogen was lower on used engines and was highest at maximum cylinder pressure, whilst the carbon monoxide concentration increased with engine wear.

H.M.S. "Daring."—H.M.S. "Daring," the first of the "Daring" class of destroyers, which are the largest ever ordered by the Navy, has been completed by Swan, Hunter and Wigham Richardson, Ltd., and is due to be accepted by the Royal Navy this month. The destroyer, which will join the Mediterranean Fleet as the leader of the new Second Destroyer Squadron, carries a complement of more than three hundred and has a length overall of 390ft, a beam of 43ft and an armament which includes six 4·5in calibre guns and two pentad torpedo tubes.

THE ENGINEER

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His Majesty King George VI

SUDDENLY, last Wednesday morning, the people of this country and the Commonwealth learnt to their dismay that King George VI was dead.

King George VI came to the throne on December 11, 1936, and in one way his reign strangely paralleled that of his father. For both monarchs, both men of peace, ascended the throne a few years before war broke out across Europe. In one respect the son was more fortunate than his father. As Duke of York he had been greatly interested in youth movements here and in the other lands of the Commonwealth. But, thanks, largely, to the development of science and its application by engineers to the business of war, he did not have to suffer so severely as his father the misery of seeing the flower of the youth of his peoples slaughtered on the fields of Flanders. Nevertheless, he had to hear with his people of the disaster, retrieved only by the spirited action of this nation and its Navy, of Dunkirk; and he endured with Londoners the nightly aerial bombardment that followed upon the victory of the "Few" in the Battle of Britain. Thereafter he saw how scientists co-operating with engineers and industrialists built up in this country the stocks of new and ingenious engines and other devices of war without which victory on land, sea or air could not be won; and, in due course, he was able, like his father, to welcome the coming of American armies to the aid of the Commonwealth. With his peoples all over the world he rejoiced in the final victory; and turned with them to study the difficult economic problems that peace brought in its train.

The King is the living symbol of the unity of the Commonwealth. With peace there came the opportunity for King George VI to resume visits to Commonwealth countries. He had visited Australia as the Duke of York in 1927 and Canada as King in 1939, an occasion on which he made a short stay in the United States. In 1947 he took the Queen and his two daughters to South Africa. Unfortunately, serious ill-health then intervened and a projected visit to Australia and New Zealand had to be postponed. But, as in recent months he seemed to be well on the road to a full recovery of health, the shock of the King's death has been all the more sadly felt by all his peoples.

We shall be speaking for every member of the great industry and profession we represent in expressing to Her Majesty, to our new Queen Elizabeth, to Queen Mary, to the Duke of Edinburgh, and to all members of the Royal Family the deep sympathy felt by all for them in their sudden bereavement. King George VI was by no one more respected, loved and admired than by engineers, whose work he had encouraged by consenting to become the patron of their major engineering institutions.

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ECONOMIC GROUPING OF GENERATING PLANT

IN our Seven-Day Journal last week we referred briefly to the I.E.E. paper by Messrs. Brian Donkin and P. H. Margen, on economic plant sizes and boiler set groupings on the British Grid. It is a subject of special significance at the present time when close attention must be paid to any steps that may reduce capital expenditure without affecting service to the consumer. The paper is based on the well-known generality that the capital and working costs, per kilowatt, of turbo alternators and boilers can be decreased by increasing the size of units installed, whereas the corresponding costs of spare plant and electrical interconnectors increase with the size of units, for any given degree of security of supply. Accordingly, there must be an economic size of unit for minimum total costs. None of the previous attempts to express these relationships mathematically can be well applied to a large integrated system like the British Grid and the present paper was therefore compiled for that express purpose. It takes account of the need for designing plant that starts its life on base load duty but may have to be relegated to regular shift operation when it becomes older and is superseded by more efficient equipment. It also makes allowance for reserve capacity requirements and the costs of interconnection to maintain a given security margin for the conditions that apply on the British Grid system. Then, having analysed the component costs, the economic plant sizes are determined by applying Kelvin's Law, that is, by summating the appropriate costs, differentiating with respect to plant size, and equating to zero. In the result it appears that the optimum plant size is not less than 100MW, except in very lightly loaded areas. Indeed, the author's assumptions are probably, as they suggest, conservative, in that the costs allowed for security interconnections are too heavily weighted. If that were so the effect would be to raise the optimum value still further.

Having established the best plant sizes, the paper goes on to discuss the factors that affect the economic grouping of boilers and turbo alternators: weight is given to plant availability and the losses due to planned and forced outage of plant and allowances is made for the cost of electrical interconnections. From these considerations the picture that emerges is broadly as follows. First it is apparent that the addition of spare boilers will be uneconomic, the more so as improvements in the design, operation and maintenance at once tend to be reflected in enhanced boiler availability. Secondly it would appear that there is full justification for the cross-connection of boilers in pairs, the net annual reduction in costs being £36·1 per MW; an even greater saving of £48·2 per MW could be realised through cross connection of all boiler units by a simple tie-bar. Finally, the comparison between one or two boilers per turbo-alternator shows that the unit arrangement with a steam tie-bar provides the most economic of the six groupings analysed in the paper. If these conclusions are true in what the authors refer to as "stable economic conditions," they are doubly true

in the present stringent circumstances when limitations on capital outlay compel engineers to seek the maximum kilowatt output for each pound spent.

Any doubts that there may be about the validity of various assumptions made by the authors cannot detract from the value of the paper. On the contrary, they merely emphasise the need for acquiring and disseminating more data on the design and operational aspects of large plant units and their auxiliaries, in the hope that, when enough experience has been gained, more precise weight can be ascribed to factors such as those involved in the relationship between fuel quality, availability for shift and base-load working, and capital costs. And what of the wider implications of this paper? The authors have shown the possibilities of using mathematical analysis to obtain more accurate results than those derived by empiricism. How far can one proceed towards the goal (suggested by Professor Kapp's contribution to the discussion) where actuarial methods can be applied to the task of determining the expectation of life of generating plant, and the risk of outage at various stages in that life? The procedure is certainly valid in the analysis of electricity consumption trends, the incidence of individual maximum demands and the effect on the overall maximum demand: there a representative sample can be taken to be indicative of the habits of millions of consumers. But a statistical approach may be less practical when one is dealing with a total of a few thousand turbo-alternators and a like number of boilers of various vintages. More fruitful results may be expected, perhaps, by trying to apply statistical methods to auxiliary plant—motors, contactor starters and relays—each numbering hundreds of thousands of a given species. It is an interesting speculation and, perhaps, something more than academic dream.

DISCOVERY AND INVENTION

THE importance of encouraging to the utmost the arts of discovery and invention on the part of any densely populated state, especially an island state, can hardly be too strongly stated. The problem is how best to achieve this desirable end. Of the intensity of this need Britain itself is a striking example. Our proportion of home-grown food has often been as little as one-third of the whole, and it has rarely exceeded a half; the balance has to come from overseas in exchange for whatever exports we can send or the services we can render. But in effecting such exchanges we are always liable to the disadvantage that whilst the food we import is vital to life, it is difficult to impart to the goods we supply or the services we render anything like the same degree of urgency. Hence, we must needs do all we can to make both these kinds of export as attractive as we possibly can. We have to sell in a highly competitive market and it is necessary to make the fullest use of any form of inventive ingenuity in these fields that we may happen to have. Our record in fundamental scientific research stands high, and in those instances where the application of the discoveries so made follows fairly directly — radar may be cited as a good instance—we have an excellent record. But much has been said in the way of criticism in respect of our alleged slowness in developing sufficiently rapidly, in the less simple cases, the applications of new discoveries even though the basic scientific work may have been largely or wholly British in origin.

One of the features of this sort of criticism is the suggestion that there should at once be made a very substantial increase in our output of highly trained technologists; some have gone so far as to make the assuredly unwise proposal that this could best be done by the creation of a new type of "university," having as its sole purpose the production of a very large number of such men, rather than in relying in the main on existing universities to fill our needs. But whatever the merits that such highly specialised educational centres might have they cannot rightly be called "universities." Their true function would be to act as post-graduate colleges, located preferably near to the industrial centres served, to which those could go who had already been to a university and who wished to qualify themselves to become technical experts in some branch of industry. This at present they can do, subject to some limitation in numbers, by attaching themselves to existing institutions, such as the Imperial College of Science and Technology at South Kensington, though if much greater numbers require such instruction the scale of existing colleges of the kind would need to be much enlarged. If this were done care would have to be taken to ensure that the instruction was everywhere kept really abreast of current industrial practice, a need most simply met by arranging that leading experts in industry should give short courses as visiting lecturers.

Experience alone can show whether attendance at a post-graduate college of this kind would be a better means of preparation than is obtainable by going straight from university graduation into industry; the latter plan might well prove much the better in the case especially of new and rapidly developing techniques. Our existing system, whatever defects it may have, has not prevented this country from assuming the lead in the production, for instance, of the most modern types of jet propelled civil aircraft—where we are some years ahead of all other countries—or in the manifold uses of radar. That leading position we must maintain as long as we can, and be on constant watch for opportunity to seize other such openings as the world's needs or our own ingenuity may suggest. If we can do this, as we have fairly successfully managed to do it since the early days of the industrial revolution, we shall be able to induce other countries to be willing, even eager, to supply us with the food and other raw materials which so large a population, with its ambitious social structure and the furnishing of its essential means of military defence, must require for its continuous and efficient maintenance. If this is thought to be a somewhat unstable mode of progress for a dignified nation, a kind of international tight-rope walking, it can be claimed that the common art of walking on one's very own feet is itself an example of a natural type of instability controlled by appropriate mental action at the right moments. In any case, if our new Government is considering the introduction of legislation to authorise expenditure for the creation of new technological colleges of any sort, we do earnestly hope they will not think it unfitting that they should first seek the advice, and even the concurrence, of the councils of our leading engineering institutions, than whom none combine so well knowledge, wisdom and experience in such matters.

Literature

Cornish Engineers. By BERNARD HOLLOWOOD, illustrated by Terence Cuneo. 1951. Holman Bros., Camborne, England, published for private circulation.

THIS sumptuous volume is really the life story of the firm of Holmans, the commemoration of 150 years of existence of which took place on May 29th; this occasion is clearly indicated by the frontispiece, showing the members of the firm—five generations indicated by portraits on the wall and by the living representatives gathered in the board-room. But the volume is much more than this, as the title indicates. It is a scholarly account of the rise and fall of Cornish mining as far as concerns the firm's fortunes. In fact, it starts with the great figure of Trevithick at work on his first road locomotive. Incidentally, for greater effect, perhaps, the author telescopes the account of the steam carriage. It was on Christmas Eve, 1801, that it was tried on Beacon Hill, Camborne, but it was not until December 27th that it was taken out to Tehidy but broke down and was left in a shed while Trevithick and his company adjourned to an inn and "comforted their hearts with a roast goose and proper drinks, when forgetful of the engine, the water boiled away, the iron became red hot and nothing that was combustible remained either of the engine or the house."

The history opens with Nicholas Holman (1772–1862), who was Trevithick's boiler maker, and follows the fortunes of what has always been a family business. Nothing is more noticeable than the way the firm has responded to the changes, to which we have alluded, that have overtaken the area. The firm built boilers of all kinds, Cornish engines, air compressors, rock pulverisers, cranes, lifting jacks, in fact, mining machinery of every description, but rock drills have proved to be its outstanding production. This began in 1881 with the patent of James McCulloch, John Henry Holman and James Miners Holman, and their drill won the silver medal at the Royal Cornwall Polytechnic Jubilee Exhibition in 1882. This created what was practically a revolution in speed of drilling. Then, in 1892, came the Leyner hammer, which was taken up by Holmans and brought them such awards as £2500 at the World Rock Drilling Contest of the South African Chamber of Commerce in 1902. While the exhaust increased ventilation, the dust caused the dread silicosis, which had to be mastered. This volume is not a history of rock drilling. But it is germain to point out that at its works the firm has a museum of examples of all the drills made and those still made, besides the applications of pneumatic tools, which are now legion. Altogether this is a fascinating chapter in our island story. Nothing is more apparent than the goodwill among all concerned: the directors, the foremen and the staff; their pride in the firm and the spirit in which all work as a team. Long may the firm flourish!

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

ASSESSMENT OF LOCOMOTIVE PERFORMANCE

SIR,—I have noticed with interest the letter addressed to you by Mr. J. Munnion, printed in THE ENGINEER of January 18th, on the above subject. Since the remarks made refer to the performance of the late Sir Nigel Gresley's "A 3" and "A4" "Pacifics," I think the following particulars relating to the power developed in the cylinders at various speeds and rates of cut-off may be of interest and possibly some assistance to your correspondent. The experimental data presented refer to a "Pacific" class "A 3" engine, No. 2751. (See Mr. B. Spencer's paper, Institution of Locomotive Engineers, 1947, "The Development of L.N.E.R. Locomotive Design, 1923–1941.")

Performance of Pacific Locomotive, Class "A 3" (L.N.E.R.)

1	2	3	4	5	6
Speed, m.p.h.	Indicated horsepower	Cut-off, per cent	Tractive force, lb per lb mean effective pressure	Indicated tractive force, lb	Mean effective pressure lb per square inch
43·0	1,503	30	177	13,100	74·0
57·0	1,536	25	177	10,100	57·2
63·25	1,413	20	177	8,390	47·2
75·0	1,467	20	177	7,330	41·6
87·0	2,550	(20) 30/35 (about)	177	11,000	62·2

Columns 1, 2 and 3 are based on actual experimental data and the remaining columns, 4, 5 and 6 give the engine constant, the estimated cylinder tractive force corresponding to the i.h.p. and speed (m.p.h.), and the mean effective pressure being column 5 divided by column 4, the data given for the speed of 87 m.p.h. when 2550 i.h.p. is said to have been developed at 18 per cent cut-off are taken from the letter from Mr. Munnion, who suggests the actual cut-off would be 20 per cent when the mean effective pressure is stated to be 60 lb per square inch.

It will be observed that at a speed of 75 m.p.h., 316 r.p.m., the actual mean effective pressure, being the average for the three cylinders, was 41·6 lb per square inch; such being the case, I suggest it would not increase to 60 lb per square inch at the same cut-off and at 366 r.p.m. In practice, mean pressures would be expected to diminish. At 43 m.p.h., or half the speed quoted, and at 30 per cent cut-off, the mean pressures are 74·0 lb per square inch. In view of the fact that mean pressures fall relatively slowly in relation to speeds after about 200 r.p.m. and at cut-offs of 30 per cent and less, I am inclined to think that at 87 m.p.h., 366 r.p.m., and assuming a cylinder horsepower of 2550, the cut-off required would probably be about 30 to 35 per cent to develop a mean effective pressure of 62 lb per square inch.

It may perhaps be remarked that port openings at short cut-offs of 18 or 15 per cent are little, if anything, above "lead" openings with any form of radial valve gear. This very materially detracts from the powers developed at high speeds and short cut-offs. Hence, there is a tendency to increase "lead" openings as being the only means of getting steam into the cylinders at the shorter rates of cut-off.

Experiments carried out by the Indian Government Railways indicate a considerable advantage by an increased "lead" opening, but it should be noted that any gain in mean pressures is seen only at early rates of cut-off and diminishes rapidly as cut-offs are lengthened till at 30 per cent or more the effect of increased "lead" practically disappears. The truth is that valve gears as commonly used handicap cylinder performance, which will not be improved till we have a valve-operating gear that will give vastly better port openings for admission at running economical cut-offs, so augmenting mean effective pressures which produce the pull required to accelerate high-speed trains. Though it is a fact that the valves and valve gear, next to the boiler, decide locomotive performance, it is also a fact that, with a few notable exceptions, little practical interest is taken in the development of improved valve gears for locomotives, whereas in modern high-class stationary engine practice this aspect of design received, in days long past, considerable attention, as is also the case with present-day practice in I.C. engine design for all purposes.

E. C. POULTNEY

Haverstock Hill, N.W.3,
January 28, 1952.

SIR,—The idea that the performance of the steam locomotive can be stated in precise terms and tidied up by neat mathematical equations and empirical formulæ when applied to given cases is fallacious; it is only possible to arrive at an approximation at best.

In estimating the resistance to traction at various speeds of a passenger train, what is easier or more tempting than to take an equation of the $T=a+bV+cV^2$ type with constants given by some well-known experimenter and so derive figures in pounds per ton of train weight for various speeds. Then, by multiplying each by the total weight of the vehicles the total resistances at those speeds on the level are estimated. This equation, however, presupposes that the train in question is composed of the same number and type of vehicles as the test train and that it runs in still air. The first and last vehicles have a higher air resistance than the intervening ones, so that a short train has a higher resistance per ton than a long one, and the general equation no longer applies to either case. The synthetic approach to train resistance made by Carus Wilson was more realistic, in that it took into consideration a number of variables.

If there is a head or following wind of W miles per hour the resistance formula becomes $T=a+bV+c(V\pm W)^2$, and while some allowance for it can be made, if known, the effect of wind on the side or at an angle to the train is incalculable unless the line is straight and traverses flat, open country.

The inclusion of the weight of passengers and luggage to base resistance on the gross weight of train is quite illogical, although frequently taken into account, as the third term of the equation is mainly concerned with air resistance, and the load carried by the train has little effect on the first and second terms. The third term is unaffected unless luggage is carried on the roof, as of yore, and passengers lean out of the windows! It is better to assume the tare weight where resistance is concerned, but the load must be taken into account on gradients and in kinetic energy; the latter should also include that stored in wheels, axles and train lighting dynamos, but no mention of this was made in Dr. Tuplin's article (THE ENGINEER, October 12, 1951). Attempts to translate published records of drawbar pull into drawbar horsepower at the speed recorded are liable to some error unless the pull is first corrected for inertia. At high speed very minor changes in speed, difficult to detect, can appreciably raise or lower the pull over that for overcoming resistance and gradient. British Railways have built a most elaborate and expensive test train equipped with automatic braking to hold speed constant and so eliminate this troublesome effect altogether.

The assessment has been solely concerned with the locomotive, but in practice the track is not without its influence, and tracks vary considerably, some having such easy curves as to differ little from the straight. Others are continually bending to left and right alternately, so that curve resistance is set up in the train. Apart from this, the bed of the track depresses under load; the amount varies, but I believe $\frac{3}{16}$in is considered the optimum. Due to the depression the locomotive has to lay down the track continuously, mounting a slight gradient in doing so, while the opposite occurs behind the rear coach to balance affairs at slow speed. At high speed the inertia of the track enters into it, making the bed harder to depress and slower to recover, so that the compensating gradient at the rear is lost. Thus resilience and inertia play their parts.

As an illustration of the influence of the track on performance, I carried out a series of tests with the same engine, enginemen, class of coal and train weight, first from Waterloo to Salisbury and back, and then Victoria to Dover and back, under fair weather conditions. Notwithstanding that the Salisbury trip was a few miles longer and was timed at slightly higher average speed, it required about 3 per cent more coal and water to run the Dover trip. The line between Tonbridge and Sandling on the Dover road is particularly straight, so curve resistance could not have been wholly responsible.

Another indication that one road is harder on the locomotive than another is reflected in tyre wear. Records kept at the time when "King Arthur" class engines were running on all three sections of the Southern Railway gave the following information in regard to mileage per $\frac{1}{4}$in loss of thickness of coupled wheel tyres due to wear and re-turning to profile:—Western, 59,000; Central, 37,000; Eastern, 22,000, the inverse ratios being 1·0, 1·6 and 2·7 respectively.

Train resistance formulæ are of great use to designers and others to enable performance to be estimated. Additions can be made to meet gradients, curves or other adverse conditions, and a margin added for contingencies such as unfavourable weather. When the reverse is attempted and the formulæ applied to actual cases, there are a number of unknowns, as instanced above, which can invalidate the conclusions drawn.

In the final assessment Dr. Tuplin gives a figure for estimated drawbar horsepower per square foot of grate, to bring matters to a common denominator. This nominal figure short circuits such pertinent factors as calorific value of coal, rate at which it is consumed; efficiency of combustion, of the heat-absorbing

capacity of the boiler and superheater; efficiency of the blast pipe, of the cylinders, the internal and external resistances of the engine and that of the tender, and the skill of the enginemen. Therefore, there is nothing to indicate that the figure obtained represents a good performance or a bad one.

The continuous production of 45 indicated horsepower per square foot of grate is considered to be a good performance. Under normal conditions about 13 of this would be required for the propulsion of the engine and tender, leaving 32 for the train. When Dr. Tuplin estimates as much as 49 drawbar horsepower per square foot, it can only represent a temporary overload in which steam generation by combustion on the grate is supplemented by the thermal storage of the boiler, a source unrelated to grate area. In fact, to take the matter to extremes, locomotives are built for special duties with 100 per cent thermal storage and no grate at all. In this case his rating would reach ∞.

H. HOLCROFT

Chipstead, Surrey,
February 2nd.

COAL-BURNING GAS TURBINES

SIR,—In your issue for January 18th, the contributor under the title "A Review of Gas Turbine Progress, 1951," suggests that the opening of large refineries in this country may tend to reduce the considerable interest at present being shown in coal-burning gas turbines. His remarks brought to mind the fact that South Africa has rarely been mentioned in the Press as a potentially large export market for gas turbines.

During a recent very brief visit to the Union, I noted an encouraging degree of gas turbine-mindedness in high places. Whilst taking only academic interest in oil-burning plant, all concerned were keenly watching coal-burning developments and seemed prepared to display very active interest as soon as practical success had been demonstrated.

With no indigenous oil fuel, coal in quantity and at a price such as to make thermal efficiency a secondary consideration, and cooling water non-existent in some areas or already tapped to capacity in others, a reliable coal-burning gas turbine could undoubtedly be a very serious rival to steam and diesel plant not only for power generation, but also for locomotion.

Whether or not there are other overseas markets comparable to South Africa in this respect, it seems clear that the fully developed coal-burning gas turbine is a potentially very valuable commodity even if the future fuel position in this country should cause it to be labelled "for export only."

T. G. HICKS

London, W.1,
January 30th.

Europe's Industrial and Economic Position

THE research and planning division of the United Nations Economic Commission for Europe has now completed its fifth annual *Economic Survey of Europe*. The survey analyses the economic and industrial position of Europe during 1951.

In Western Europe, the survey states, industrial production last year was affected rather less than expected by raw material shortages, but it was also restrained in the middle of the year by a decline in consumer demand. It is suggested that when figures for the full year are available, the increase in total industrial production in Europe as a whole will prove to have been a few points less than the 14 per cent recorded in 1950. The survey adds that both in agriculture and in industry the two parts of Germany, East and West, increased production more than nearly all other countries. In industry, Eastern and Western Germany together provided about one-half the total increase in European industrial production. At the other extreme, the United Kingdom, where raw material shortages were most marked, contributed only about one-tenth. France, Belgium and Italy, whose combined output in 1950 was in absolute terms substantially less than the United Kingdom's, contributed twice as much to the increase in 1951. The rates of increase which these countries achieved in the greater part of the year emphasise the extent to which they had previously been failing to make full use of their existing industrial resources.

In the United Kingdom and Scandinavian countries industrial production in 1951 rose moderately because reserves of manpower were relatively small and because the rate of increase in production per man-year slowed down. These countries, it is suggested, were endeavouring to apply increased quantities of labour to capital resources which were already almost fully utilised and, in the case of the United Kingdom, with inadequate supplies of raw materials. It is estimated that, by the third quarter, output per man-year in the United Kingdom had fallen to a level no higher than that of the corresponding period in the previous year. In other Western European countries, the survey says, production could expand much more than in Northern Europe partly because there existed larger and, in some cases, abundant manpower reserves, and partly because output per man-year in the period before the Korean war had been at a rather low level owing to the low utilisation of the existing stock of industrial capital. In these countries, output per worker seems to have increased in 1951 by about 10 per cent in each case, and in all of them except France and Italy employment likewise increased substantially. In Eastern European countries, it is thought that the increase in employment was considerably greater than in the West, the indications being that working hours also may well have increased considerably.

Dealing specifically with the engineering industries, the survey notes that last year there were considerably increased demands for the engineering products of Western Europe, and says that these demands were met with "relative ease." At the end of the year, it is stated, there remained, in several Western European countries, branches of the engineering industry where producers were more than anxious to obtain new orders and where a buyers' market could be said to exist.

The high prices for primary products increased very considerably the purchasing power of countries which produced them, and most of these countries wished to spend a large proportion of their increased earnings on capital goods for development. Equally important, the survey declares, was the behaviour of private industry in Western Europe, which in nearly all countries took the opportunity, soon after Korea, to buy plant and equipment which it feared would not be obtainable later; there were also present all the conditions for a rise in home investment induced in the normal way by a general upswing in economic activity. Finally, rearmament played its part. Statistics show that investment—and rearmament—inside five European countries, and their exports to overseas countries maintained the shares they held in 1950, although the experience of the individual countries varied considerably. In France, Italy and Western Germany, the pull from export markets was by far the strongest element, but in the United Kingdom both exports and home deliveries were held down by factors on the supply side. The survey observes that in general the effects of rearmament in the engineering boom during the first nine months of 1951 do not seem to have been very great.

According to the survey, in the United Kingdom and the Scandinavian countries production capacity was already more or less fully occupied and output last year could rise by no more than was allowed by such increases as there were in the labour force and in raw material supplies and by the technical improvement in productivity. In these countries as a whole, engineering production rose no more than 5 per cent from 1950 to 1951 (based on the first three-quarters of each year). Though their output currently makes up about 40 per cent of total Western European engineering production, they accounted for only about one-sixth of the increase in the total over this period. The engineering industry of the United Kingdom was affected by reconversion and afflicted by a shortage of steel; employment rose steadily, it is remarked, but production did not keep pace.

The boom in the engineering industries of Western Europe, combined with large unusual demands from the United States and considerable, though unsatisfied demands from other overseas countries, produced a condition of substantial inflation in the Western European market for steel. Prices rose and delivery periods lengthened. The survey suggests that, over the whole of 1951, Western European crude steel production totalled about 12 per cent more than in 1950. New plant completed during the year in the United Kingdom and France, together with steps taken to reactivate plant in Western Germany, should have provided enough capacity in Western Europe to produce 7 per cent more crude steel than the estimate of the output for 1951, but Western European capacity could not be fully used because raw material supplies were inadequate. Production of finished steel increased by more than production of crude steel because stocks of ingots and semi-finished steel were run down in several countries, particularly in the United Kingdom and Western Germany. The survey shows how a very substantial part of the increase in Western European steel production since Korea has been exported to the United States and Canada. Home markets in Western Europe received relatively moderate increases in supplies, and the primary producing countries outside North America, although they obtained 15 per cent more steel from Europe in the second half of 1950 than in the first, experienced an actual reduction in supplies in the first half of 1951.

Lloyd's Register of Shipping

LLOYD'S REGISTER OF SHIPPING has issued its 1952 edition of the Appendix to Lloyd's Register Book. The statistical tables, based on the entries in the Register at July, 1951, include a list giving the gross tonnage of the principal merchant fleets of the world and indicating the change in the totals compared with 1950. The world total at 87,245,000 tons is 2,662,000 tons greater than the previous year and the following countries show the largest increases: Germany, 571,000 tons; Norway, 360,000 tons; Italy, 337,000 tons; Great Britain and Northern Ireland, 331,000 tons; Japan, 311,000 tons, and Panama, 248,000 tons. The total return for the British Commonwealth excludes the Irish Republic for the first time. Compared with 1939, the largest increases are noted for the United States of America, namely, 15,970,000 tons; Panama, Norway and the Argentine, while decreases are recorded for Germany, Japan, Italy and Greece. Regarding size and age, the preponderance of ships of 6000 to 8000 tons still reflects the effect of the war-time building programme, however, many of these ships are not in commission. Since the war the largest amount of tonnage built falls within the groups 8000 to 10,000 tons and 10,000 to 15,000 tons. Of the world total there is an increase in numbers of ships between 10,000 and 20,000 tons from 496 in 1939 to 1128 in 1951, of which 818 are oil tankers. Ships of 20,000 tons and upwards have decreased in numbers from eighty-two in 1939 to sixty-six in 1951, forty ships of this size are being built in the United Kingdom in the current year, two fewer than in 1939. Of the tonnage, namely, 13,200,000 tons, under five years of age the United Kingdom has the largest share, with 3,800,000 tons followed by Norway with 2,200,000 tons. Motorships form 27 per cent of the world

tonnage, an increase of 2 per cent over 1950, but for individual countries the percentage shows wide variations. In Norway and Sweden motorships account for 74 per cent and 70 per cent, respectively, of the tonnage owned, the figure for Great Britain and Northern Ireland is 36 per cent, while for the U.S.A. it is 4 per cent. Oil tankers over 1000 tons gross increased by 1,344,000 tons since 1950, to total 18,210,000 tons, which represents 22 per cent of all steamers and motorships as compared with 21 per cent a year ago. The ships burning oil as fuel now amount to 83 per cent and the 17 per cent which depend on coal compares with 45 per cent in 1939 and 97 per cent in 1914. The number of merchant ships entered in the Register Book, at the end of June, 1951, totalled 9729 of 36,267,000 tons gross and represented nearly half of the world total.

Refrigerated Wagons for International Transport

LAST week two new refrigerator wagons for the international transport of perishables were exhibited at Victoria Station, London, by the Société Ferrovaire Internationale de Transports Frigorifiques, or "Interfrigo," as it is now generally known. This international railway-owned company for refrigerated transport was formed by the railway administrations of Western Europe in 1949, and is concerned with the construction, hiring out and operation of rolling stock and plant for transporting perishables. New wagons, designed by the technical staffs of all the member companies, have been built in France, Belgium and Switzerland to supplement the stocks of existing wagons which the company has been operating since October, 1950. The two new wagons exhibited incorporate the latest developments in refrigerated transport; one is fitted for the transport of meat and the other for other goods such as fresh fruit and vegetables. Of the 350 wagons being built to standard 4ft 8½in gauge now under construction, seventy are being fitted with meat bars and hooks. Each body has a volume of 1095 cubic feet with a floor area of 183 square feet, and is designed to take about 14 tons of goods. At each end of the wagon body is a bunker for ice and the air is circulated round the vehicle by a number of fans in the roof. These ventilating fans are mounted on ball bearings, and are rotated by external vanes projecting above the roof level as the vehicle is moving. The floor, walls and roof of the wagon are heavily insulated and the coefficient of thermal conductivity is stated to be 0·49. Each wagon has a tare weight of 17½ tons and is fitted with compressed air and automatic vacuum brakes.

BOOKS RECEIVED

Electricity in Transport. London: The English Electric Company, Ltd., Queen's House, Kingsway, W.C.2. Price 12s. 6d.

Autobiography of Robert A. Millikan. London: MacDonald and Co. (Publishers), Ltd., 16, Maddox Street, W.1. Price 21s.

Electric Lighting. By C. E. Gimson. London: Cleaver-Hume Press, Ltd., 42a, South Audley Street, W.1. Price 9s. 6d.

Soil Testing for Engineers. By T. William Lambe. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 40s.

Fuel Oil Manual. By Paul F. Schmidt. London: Bailey Brothers and Swinfern, Ltd., 26–27, Hatton Garden, E.C.1. Price 30s.

A Guide to Plastics. By C. A. Redfarn. London: Iliffe and Sons, Ltd., Dorset House, Stamford Street, S.E.1. Price 7s. 6d.

Vibration and Shock Isolation. By Charles E. Crede. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 52s.

Dollars and Industry. London: British Electrical and Allied Manufacturers Association, 36 and 38, Kingsway, W.C.2. Price 10s. 6d.

Engineering Thermodynamics. By Herman J. Stoever. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 46s.

Electroplating and the Engineer. By Alan Whittaker. London: Emmott and Co., Ltd., 21, Bedford Street, W.C.2. Price 4s.

Reconditioning an Old Jetty

The jetty whose reconditioning is described was originally built in reinforced concrete. In 1920 a timber extension was added. The jetty had to be under-pinned by reinforced concrete piles in 1933. The state of the materials throws light upon the behaviour and relative merits of older forms of jetty construction. The reconstruction work is interesting on account of the novel form of the replacement structure.

AN interesting repair job has recently been carried out upon Settle Speakman and Co., Ltd.'s coaling jetty situated in the tidal creek which separates the Isle of Sheppey from the mainland close to the point where the River Medway debouches into the Thames Estuary near Queenborough, and of which a general idea can be obtained from Fig. 4.

This reconstruction work is interesting both on account of the novel form of the replacement structure that has been newly installed there and also on account of the object lesson the jetty affords as to the behaviour and relative merits of several older forms of construction which had been established there at different times during the past half century.

The original jetty built in reinforced concrete consisted of the curved approach gantry shown in Fig. 3, supported on piles and carrying two lines of railway leading to a piled jetty or wharf 185ft long, where the two lines of railway were straddled by outer rail tracks intended to support 3-ton grabbing cranes of the portal type (see Fig. 1). The wharf also supported a coal conveyor mechanism on its rear or inner side. The front of the wharf was fitted with timber fenders and provided berthage for coal ships, there being a depth of 33ft of water in front of the wharf at high water of spring tides. The rear side of the wharf was intended for the berthing of barges which went aground at time of low water, the tidal range being 19ft at springs. This original part of the jetty, built in 1907, is a typical example of one of the early efforts at wharf construction in reinforced concrete.

An extension was built in the year 1920, increasing the effective length of the wharf by 120ft. It is significant that there was a reversion to timber as the constructional material for the extension. Then, in 1933, when both the original reinforced concrete portion and the timber extension were showing signs of collapse, an underpinning scheme in reinforced concrete was designed by Messrs. Peter Lind and Co. and was put into execution by them.

Messrs. Peter Lind and Co.'s underpinning work involved the driving of forty-eight

FIG. 2

new reinforced concrete piles to reinforce the thirty-nine piles of the original concrete jetty and also the driving of thirty-two new concrete piles to bolster up the forty-two timber piles of the timber extension.

The new concrete piles were 16in square, whereas the original concrete and timber piles had been 12in square and the length of the new concrete piles, which was between 60ft and 70ft, considerably exceeded the length of the original concrete and timber piles.

The old reinforced concrete and timber deck structure was retained in the 1933 reconstruction, it being supported by the heavy concrete capping of the underpinning system. In the year 1938, however, the old deck system showed such serious signs of further deterioration that the owners, Settle Speakman and Co., Ltd., undertook the task of resurfacing the underside of the concrete deck and the sides of the beams with fresh concrete. This work, which was carried out with much

FIG. 1

FIG. 3

FIG. 4

patience and skill, was proceeding little by little when the incidence of the war put a stop to it, so that actually only half of the length had been refaced when the stop occurred.

The general position which the wharf presented, therefore, to an observer after the war was that of an old reinforced concrete structure, much of which was in a state of decrepitude linked to a timber extension which was also in a bad state, the whole being propped up by the reinforced concrete piles and by the heavy concrete capping of the underpinning structure of 1933, the latter remaining in fairly good condition.

It is instructive in retrospect to consider some of the causes which may possibly have operated to bring about deterioration of jetties such as this one built about the turn of the century, that being the period when reinforced concrete first came into fashion as a material for building wharves and jetties.

The idea which the early designers of jetties started out to pursue was the reproduction in reinforced concrete of a kind of replica of the timber structure that had been in use for many years prior to the appearance of reinforced concrete—that is to say, they set out to design a three-dimensional lattice structure, the vertical members consisting of piles with columnar extensions upward, and the horizontal members, both longitudinal and transverse, being arranged usually in two layers, the upper layer above high water at or near deck level, and the lower layer just above low water.

Between the horizontal and vertical members they disposed longitudinal and transverse raking members. Below low water there was as a rule no cross bracing.

In some cases they did not fully utilise the properties of the continuous deck slab, whereby the whole structure can be knit together, so letting slip one very great advantage which the reinforced concrete structure possesses over its timber prototype.

The way in which this early kind of reinforced concrete structure was carried into execution was for the piles to be driven first and left with their heads projecting above low water. After driving, the heads of the piles usually in a damaged state were stripped down to expose the bars and carpenters were employed to make, fit and fix shutters on top of the piles. Within the casings so provided, steel fixers would afterwards place reinforcing bars and eventually concreters would pour concrete to form the finished column pile extensions, the horizontal walings and the diagonal bracing members.

The whole of this intricate process of shuttering, bar fixing and concreting work had to be performed from temporary scaffolding in very exposed positions over deep water, during working hours that were limited to periods of low tide. In carrying out such operations it was frequently found to be necessary to work at night time by the light of flares, and it usually happened that the concrete, after being deposited and before it had time to take its initial set, was covered over and washed by the rising tide water.

It is impossible to withhold admiration from the contractors of those days (not really so very long ago), who were prepared to undertake to build in such conditions and who, in spite of all the difficulties, usually succeeded in carrying the work into effective execution.

Another peculiarity affecting the early reinforced concrete work carried out prior to the 1914 war was the extraordinarily competitive system which prevailed whereby the authority or private owner, having decided to build a structure, frequently invited competitive designs from various firms of reinforced concrete specialist designers as well as obtaining competitive tenders from numerous firms of contractors for the carrying out of the work.

After a jetty of this kind had been built it was regarded by shipmasters and watermen as a new-fangled contraption and a fair target against which, in their more elevated moments, they took pleasure in pitting the proven strength of the sturdy craft they navigated, both ships and barges, by coming alongside in no gentle manner.

Having regard to all the above considerations, it is not surprising that some of the early reinforced concrete wharves should have suffered more rapid deterioration than their modern counterparts are expected to do. In the case of this particular structure, it is remarkable that some parts of the original concrete work still remain in good condition and are in effective use to-day. This is an indication that the design and the

FIG. 5

FIG 6

execution work must both have been fundamentally good and carefully performed.

Where the wharf extension was concerned, the case is rather different. A timber jetty built of the right kind of timber and put together in the right way, a way which was very well understood a hundred years ago, ought to have lasted in fairly good condition for forty or nifty years, whereas in this case it has not done so. The piles and other timbers are completely, or almost completely, eaten away by marine borers round about the zone of low water mark, and many of the timbers at deck level above high water mark were also found to be in a rotten condition through contacts with deck filling and other timbers, whereby joints between timbers lay wet and could not dry out properly between the rainstorms.

The quality of the timber was probably partly to blame, because the timber actually employed was not greenheart, nor long-leaf pitch pine, but what is known as Douglas fir timber imported from the State of Oregon, U.S.A., or from British Columbia, and it was not creosoted under pressure before being erected.

The rise of the reinforced concrete jetty into popular favour, of which earlier mention has been made, was, of course, itself due very largely to the fact that after the 1914–18 war timber, such as greenheart or pitch pine, which up till then had been in plentiful supply at a very cheap price, was hard to get and so far as pitch pine is concerned is now practically unobtainable.

Before that time pitch pine had been available at a cheap price and in suitable lengths and sizes and it constituted an almost ideal material for the construction of marine jetties, stages and other works of the moderate size then in vogue. It was light and easily handled, weight for weight it was as strong as steel, it could be more easily cut and shaped than almost any other material, and when secured by bolts two timbers could transmit stress by and through the friction of their two surfaces bolted together in contact. Pitch pine is fairly resistant to marine borers, but in places where the teredo was active it was considered better to use greenheart, the greater expense of the latter timber being justified by its greater immunity in such cases.

The accompanying photograph, Fig. 2, of the stump of one of the old piles in the jetty now under consideration, was taken near low-water level, where the ravages of marine borers are found, in our water at any rate, to be most pronounced. It is interesting to observe that the upper part of the stump above the level of high water is perfectly sound and no doubt the timber where embedded beneath mud level is also sound. It is interesting also to note that the stumps of the old piles, where they pass out of sight below the level of the lowest low-water, are attacked to a much less extent than they are attacked in the vicinity of low water.

The damage which these piles have sustained has been caused by one of the smaller marine borers, which fret away the surface of the timber, which, in the course of years, gradually contracts in size until, as in the photograph, practically nothing remains. The large worm-shaped mollusc, known as teredo navalis, works rather differently by boring through the heart of the timber in all directions, so that with teredo attack it is possible to have a more or less intact surface accompanied by nearly total interior destruction, all done in a few weeks or months.

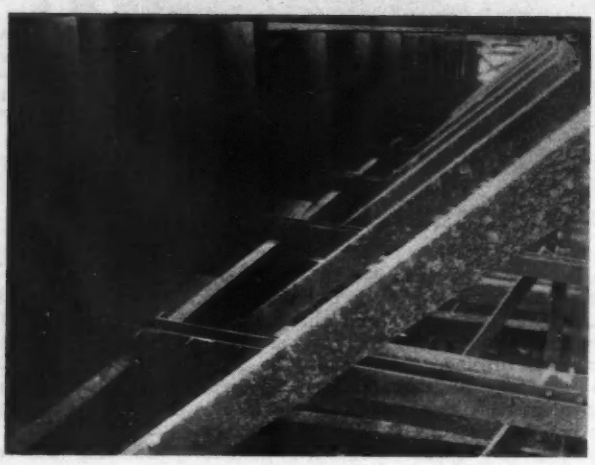


FIG. 7

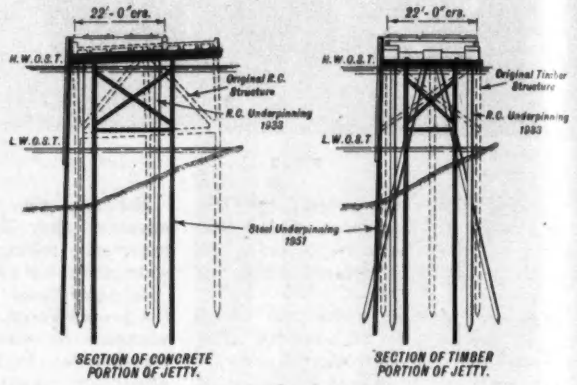


FIG. 8

Other photographs accompanying this article were taken with the intention of illustrating the nature of the deterioration that goes on in reinforced concrete. It will be noted how when cracks have once formed the rusting of the iron reinforcing bars proceeds and the pressure of rust formation spalls off the concrete covering over the bars. In some parts of this structure the process just described has in course of forty-four years proceeded to a point where the main reinforcing bars have been rusted nearly through, but more often the weakening of the concrete member through loss of concrete compression area is a more serious factor than is the positive loss of steel tensile stress area through loss of the metal eaten away by rust.

While the cracking of the concrete junctions may be regarded as a consequence of the tilting-over of the whole jetty, owing to subsidence on its outer face, the cracking of the concrete junctions shown in Figs. 5 and 6 might equally have been brought about by racking stresses inherent in and unavoidably associated with this kind of jetty design, where a fully articulated and rigidly cross-braced structure above water level is superimposed upon a totally unbraced underwater substructure of vertical pile shanks.

Fig. 8 is a cross-section of the original part of the jetty and shows in dotted line the original reinforced concrete work, in full line the remedial reinforced work carried out in 1933, and finally, in black, the steel underpinning work recently carried out.

Fig. 8 shows the same thing in the case of the timber extension, the original timber work being dotted in this case, the reinforced concrete underpinning being in full line and the recent steel underpinning in black. It is noteworthy that in the underpinning of this timber extension, Peter Lind and Co., adopted a different and much sounder method of cross-bracing the whole

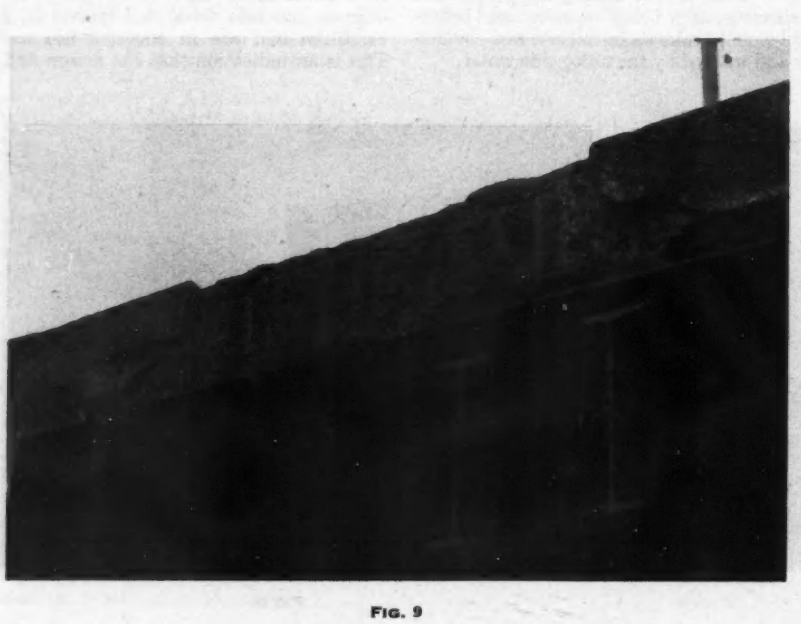


FIG. 9

FIG. 10

structure by the introduction of the raking piles shown in Fig. 8. By this means they avoided the setting up by horizontal forces of bending moments in pile shanks, and of racking stresses in pile-head junctions.

Fig. 9 is another photograph of concrete deterioration, the subject in this case being one of the old original deck beams, where flat iron stirrups had been used to contain the main reinforcement. This shows how the rusting of flat iron stirrups has had the effect of spalling off the whole of the original cover concrete on the beam side. It was noted that the spalling was much less extensive where round iron stirrups had been employed.

It remains to describe the measures of restoration-cum-betterment which the structure has lately undergone. The element of betterment comes into play as a result of the owners' desire to equip the old jetty with grabbing cranes of larger size and very much more rapid handling capacity than those previously installed.

The tool selected for this purpose was the standard 5-ton level luffing Stothert and Pitt 22ft gauge portal wharf crane and, of course, a crane of such size imposes considerably greater wheel loads and calls for more support. When the consulting engineers, Maunsell Posford and Pavry, Co., Ltd., came to view the structure as it existed in 1950, it was obvious that very few of the original reinforced concrete piles and none of the old timber piles could be counted upon to render further service. The excellent reinforced concrete piles and pile-caps installed by Peter Lind and Co. in the 1933 reconstruction were, however, in a fairly sound condition, and with a little patching up they could be expected to last for a great many years. There were, however, not enough of them to bear the locally increased loading due to the new equipment, nor were the deck beams spanning between the pile bents strong enough to carry the new loads.

From the operational point of view it was of great importance to the owners that reconstruction work should be carried out in such a way as not to put the wharf out of action as an operational unit, that is to say, they desired that there should be no interference to the berthing of ships and barges and the continuous loading and unloading of coal from ship to barge or from ship to rail, lorry or conveyor ashore.

The non-stop working condition last mentioned imposed upon the engineers the necessity for devising some neat way of driving additional piles that could be quickly and easily performed piece-meal without the introduction of heavy contractors' plant. The system which fulfilled these objects was the driving of steel piles through holes cut in the existing deck structure by means of a McKiernan Terry hammer. Piles of the new 12in by 12in broad-flanged beam rolled steel section were adopted as being sufficiently light to be handled and pitched in position by the existing 3-ton wharf cranes, times for pitching of piles being selected when interference with coal grabbing was not involved.

After being pitched the wharf crane lifted and placed in position on the top of the broad-flanged beam section pile a No. 7 McKiernan Terry hammer, there being no pile-driving leaders. The hammer, operating through a flexible steam hose, drove the pile down, the hole in the deck being sufficiently large to permit the hammer to follow through the hole to the final driving position of the head of the pile a few feet beneath deck level.

The length of steel pile was determined by experiment in the first instance. The first pile, having been driven down as far as could be, was afterwards test loaded by running a locomotive engine over the track and jacking up the old wharf deck with the locomotive upon it off the head of the steel pile.

The rather interesting and surprising result of the test was to show that a steel pile of this description, depending as it does mainly upon its frictional contact in the ground, was capable of supporting a test load of 44 tons without subsidence. It was hardly expected that a No. 7 McKiernan Terry hammer with its moving ram of only 800 lb weight would so comfortably have achieved the driving of a steel pile weighing nearly 3 tons to produce such a result. At close of driving the hammer was striking 170 blows per minute and the set per hundred blows was round about 2in.

The general scheme of the reconstruction was to duplicate the original underpinning procedure of 1933 by placing a new transverse bent of piles and beams between each of the original bents and by so doing to halve the span of the old deck beams. The new cross beams were formed out of 24in by 7½in R.S. joints disposed in pairs and connected to the heads of the new steel piles by a rough but very strong joint, into which both bolting and welding and packing entered. The joint was ultimately run in solid with concrete so as to prevent water from lying or rust from forming within the spaces between the steel members.

Fig. 10 shows the head of one of the 12in by 12in broad-flanged beam section piles where it projects through and above its junction with the 24in by 7½in steel beams to which it is connected in the way just described in the preceding paragraphs.

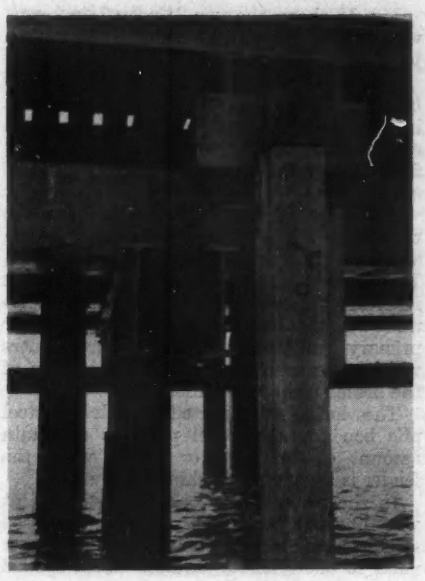


FIG. 13

FIG. 11

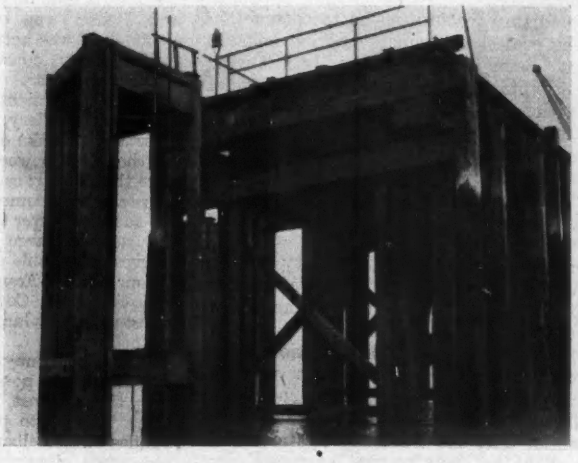


FIG. 12

Fig. 13 shows the two 24in by 7½in beams where they protrude horizontally from the junction.

Figs. 7 and 11 show the 8in by 8in angle bracings of the new steel substructure and incidentally show some of the original concrete cross bracing members which, after forty-five years' use, are still in sound condition.

A feature of the reconstruction was the use of the 12in by 12in broad-flanged beams as fender piles on the face of the structure. These new piles were connected to the deck structure at deck level, so providing a certain amount of extra support, but their primary function was to carry elm fenders which were neatly housed in the bosoms of the beams facing seawards.

The long, unsupported length of steel pile beneath deck level provides a certain amount of flexibility or spring when the fender is bumped by a ship below water.

In the restoratory work bitumastic paint was liberally used, all the new exposed steel surfaces being heavily coated and most parts of old concrete surfaces where spalled and cracked being also coated.

Another feature was the provision of a steel pile dolphin at the extreme end of the jetty, see Fig. 12.

This dolphin is supported upon Larssen No. 3 box piles, which were driven by the No. 7 McKiernan Terry hammer. The principle here is to provide a structure independent from the main wharf and cap-

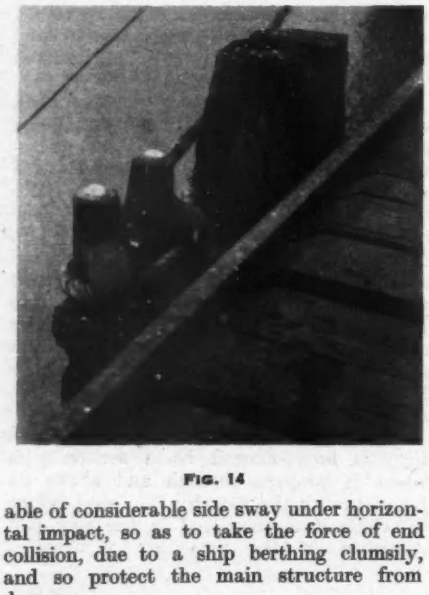


FIG. 14

able of considerable side sway under horizontal impact, so as to take the force of end collision, due to a ship berthing clumsily, and so protect the main structure from damage.

One further feature in the reconstruction was the provision of small mooring bollards of the "Bean" type (see Fig. 14). Owing to the limitations imposed by the original design there was very little room for bollards on the face of the wharf owing to the proximity of the crane track outer rail to the face of the fenders, so these bollards were actually fixed upon the top of the broad-flanged beam section fender piles above described.

The future behaviour of the jetty will be watched with interest, the principal matter for concern being the length of time which may elapse before the rusting of the 12in by 12in broad-flanged joist section piles between wind and water reaches a stage where their supporting power is affected. The broad-flanged beam section is a very substantial one, the thickness of the metal being about an inch, so that even without attention its life should be considerable, but given periodical recoating with bitumastic paint above low-water mark, it is considered that the life will be long.

The contractor who carried out the whole of the latest reconditioning and steel underpinning work was Marples Ridgway and Partners, Ltd.

South African Engineering News

(By our South African Correspondent)

Manufacture of Motor Vehicles

It would appear that motor vehicle production in South Africa will, in the near future, be appreciably augmented by the activities of several Continental manufacturers who have chosen the Union for establishing manufacturing and assembly plants.

Delivery vans of "Gutbrod" design will be manufactured in South Africa on mass production lines by the Swiss South African Engineering Corporation (Pty.), Ltd., a company recently established with headquarters in Pretoria. A large modern factory is at present under construction for the company a few miles north of the city's centre.

Swisacor has acquired the sole rights for the manufacture in the Union of all "Gutbrod" products, including commercial vehicles, light delivery vans, station wagons, combination buses for nine passengers and their luggage, passenger cars, agricultural implements and stationary diesel engines. The company is aiming at an initial production target of 200 commercial vehicles a month, and will gradually increase this output. The factory buildings now nearing completion should be ready by about the beginning of the new year, when quantity production is scheduled to begin. Within a few months of the start of manufacture complete vehicles, including engines, will be made in the factory. It is the intention to develop the project into a wholly South African industry, using South African raw materials and employing South Africans.

The first "Gutbrod" vehicles to come off the Pretoria production lines will be ¾-ton delivery vans, equipped with twin-cylinder, two-stroke engines of 700 c.c. capacity, developing 24 b.h.p. While fuel consumption will depend largely on the load carried, and the speed, the average is stated to be in the region of 35 miles per gallon.

Another company, which is at present seeking permission for the assembly only of its products, is the Hansa Lloyd Company, of Germany. The products of this company include "Goliath" cars and delivery vans, "Hansa" cars and "Borgward" commercial vehicles from ¾ ton up to the heaviest diesel trucks. At present delivery vans and station wagons are being built by a Rhodesian assembly plant and are available throughout Southern Africa.

South African Railway Developments

A new railway line between Grootvlei and Redan was officially opened recently, although it was actually in operation for coal traffic under construction conditions from January this year.

With insufficient coal reserves at the Springfield colliery, near Redan, it became necessary to make other coal sources available for the Klip power station, which generates more than 50 per cent of the electric power for industrial requirements in the Transvaal, and also supplies power to the Free State goldfields. The nearest large coalfield with adequate reserves of suitable coal is at Grootvlei, on the Balfour North-Frankfort line, where the Anglo-American Corporation of South Africa has established a large colliery, the new Springfield colliery.

So that coal may be delivered to Redan as economically as possible, a direct railway line along the shortest possible route had to be built. This route passes Platkoppies—within 16 miles of Heidelberg—so that at some future date, when circumstances warrant it, a connecting line can be built between these two points, giving a through distance by rail between them of 33½ miles. The Grootvlei-Redan line traverses good agricultural country, the eastern portion being maize producing and the western portion devoted to general farming and milk production. It is expected that as the steel and engineering industries at Vanderbyl Park and Vereeniging expand, agricultural small holdings will develop along the line within convenient distance of these two points. The line runs from east to west over more or less flat country. No major rivers are crossed, but bridges had to be built over Klip River and Suikerbosch River.

In addition to coal and other traffic, this line will carry a moderate tonnage of through traffic from the Natal main line, north of Ladysmith, to Vereeniging. The saving in through railway distance from Balfour North to Vereeniging via this line, compared with the previous route through Union Junction is 28 miles, and the route is also 2¾ miles shorter than via the alternative connection from Heidelberg to Platkoppies.

The construction of the line was started in May, 1949, and completed at an estimated cost of £1,790,802, or an average cost of £45,275 per mile. The ruling gradient is 1 in 100 compensated in both directions, while the sharpest curve is 20 chains radius. The line is built to main line specifications and new 120ft., 81 lb per yard S.A.R. rails have been laid on steel sleepers at 2112 per mile, and 2000 yards of ballast per mile provided. The length of the line is 39 miles 44 chains.

Because the supply of water for railway requirements at Grootvlei is not adequate it was necessary to construct a dam on the farm Sterkfontein, near Bosch River Station. This dam, which will have a capacity of 85,000,000 gallons, is estimated to cost £30,000 and is practically completed. The water will be pumped from the dam through a pipe-line to two 20,000-gallon water tanks at Bosch River Station, where a water purification plant has been erected.

Six overhead road bridges are at present under construction as well as a rail-over-rail bridge at a point where the new line crosses the Union-Vereeniging line at Redan. The railway bridge over the Suikerbosch River consists of six 35ft beam and concrete spans, while that over the Klip River at Redan consists of eight 40ft concrete arch spans.

Codes of Practice

The Council for Codes of Practice for Buildings—Construction and Engineering Services, is under the aegis of the Ministry of Works. Codes are issued on behalf of the Committee by the British Standards Institution, 24–28, Victoria Street, London, S.W.1.

SOIL AND WASTE PIPES ABOVE GROUND

Code 304. The Council for Codes of Practice for Buildings has now issued this code for comment, together with three sub-codes, all of which have been prepared for the Council by a Committee convened by the Institution of Municipal Engineers. These codes deal with the design and installation of soil, waste and ventilating pipes where they occur above ground, both inside and outside a building. Rainwater pipes are excluded.

In these codes stress is laid on the importance of consultation at the planning stage between all the interested parties, and lists of British Standards are included to which materials, appliances and components should conform.

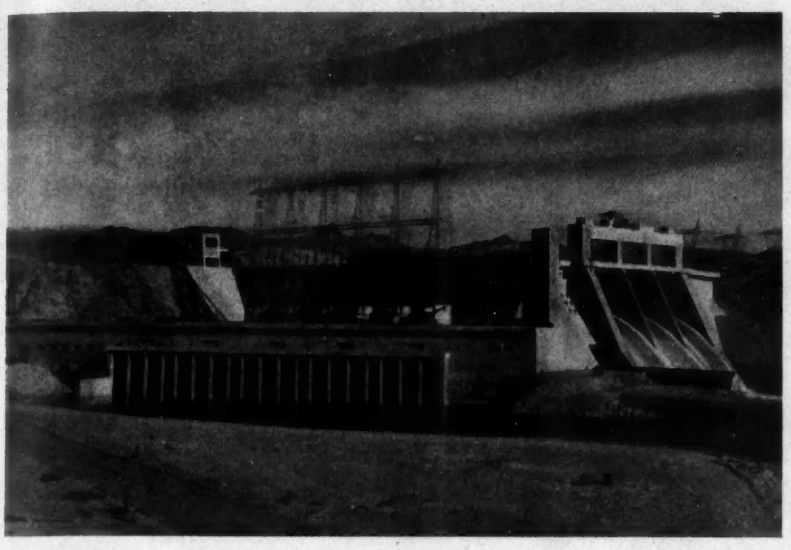
There is described in some detail the system which may be used, and recommendations are made on the lay-out of pipework and appliances, on suitable fixings for various types of pipes, on traps and ventilating pipes, on the most likely points at which obstructions may occur and on methods of ensuring easy access at these points. General information is given on various methods of jointing pipes of different materials, and suitable methods of fixing. There are notes on testing soil and waste systems for water-tightness, for hydraulic performance, and for the stability of trap seals. Advice is also included on the maintenance of pipework, fittings and fixings.

Drawings show pipe sockets, lead tacks and other fixings, also access caps and covers of various types. Tables give rates of discharge for sanitary appliances in terms of flow units. Recommendations are made for pipes sizes for soil and waste pipes and suspended drains. Price 5s. post free.

Some American Hydro-Electric Schemes of 1951

IN this article some brief notes are given of four hydro-electric projects which were completed or under construction last year in the United States. They are representative of the very large volume of this class of work which was in progress during 1951.

Civil engineering work on the Davis dam on the Colorado River was completed in 1950, but the five 45MW generators of the power station adjacent to the dam were brought into operation during last year. The Davis dam utilises the last available head on the Colorado River below a series of five dams between Hoover dam and Laguna dam, which is 13 miles north-east of Yuma (Arizona). The new structure regulates the division of the flow of the Colorado River between the U.S. and Mexico, produces hydro-electric power, and compensates the irregular discharges from Lake Mead through the Hoover power station for irrigation downstream. The Davis dam is an earth and rockfill embankment, 138ft high, with a concrete spillway, intake structure and power station. It has a crest length of 1600ft and its top width of 50ft accommodates a two-lane highway. Its reservoir has a capacity of 1,820,000 acre-feet and extends 67 miles upstream to the tail-race of the Hoover dam. Almost 4 million cubic yards of earth and rockfill were required to form the dam, and about 565,000 cubic yards of concrete were placed. The semi-outdoor power station of the project is situated on the Arizona side of the river, immediately downstream from the dam embankment, and may be observed, with the spillway structure and the dam itself, in the accompanying illustration. It has an installed capacity of 225MW in five units and is now producing about a billion kWh of electrical energy annually.



DAVIS DAM AND POWER STATION

HUNGRY HORSE DAM

By the end of the 1951 construction season 2,400,000 cubic yards of concrete had been placed at the Hungry Horse multiple-purpose project of the Bureau of Reclamation in Montana. With the closure of the diversion tunnel, storage of water has now begun in the reservoir. The accompanying illustration shows a scroll casing for one of the four 105,000 h.p. turbines being installed in the Hungry Horse power station. The first two generators are scheduled to begin production in October and December, respectively, of 1952, and all four units are expected to be "on the line" by November, 1953. Hungry Horse dam is a concrete arch-gravity structure, and will be 2115ft long at the crest and 564ft high; it will have a maximum base width of 330ft and will be surmounted by a 30ft wide road; the elevation of the crest of the dam will be 3565ft above sea level. The spillway will consist of a reinforced-concrete-lined tunnel, having a maximum diameter of 35ft, which will tap the reservoir 118ft upstream from the dam and carry the water through bedrock under the right abutment of the dam and return it to the river 550ft downstream. The maximum discharge capacity of this spillway will be 45,000 cusecs. A ring gate, with a diameter of 64ft and capable of moving 12ft up and down, will be installed in the spillway crest to control the level of the reservoir, which will be approximately 34 miles long and 3½ miles wide. It will have a total capacity of 3,500,000 acre-feet and a usable storage capacity of 2,980,000 acre-feet.

GRAND COULEE PUMPING PLANT

An important development took place in the Columbia Basin of the North-Western U.S.A. when the first pump of the Grand Coulee pumping plant went into regular operation on June 14, 1951, lifting water 280ft from Lake Franklin D. Roosevelt into a canal which flows into the Grand Coulee. The Coulee has been turned into a storage reservoir with dams at both ends, and the water will be stored there for use during the irrigation season. The first large-scale irrigation is contemplated this year, when facilities will be available for supplying water to 87,000 of the million acres of the project. Through the effect of the storage reservoir, off peak power which would otherwise be wasted, will be used to the greatest extent possible to pump the water, building up a supply which will flow by gravity to the Columbia Basin project lands during the hot, dry growing season. There will be more than 1000 miles of canals and laterals within the project. Ultimately, 1,029,000 acres will be under cultivation. Approximately 6 per cent of the flow of the Columbia River at this point will be diverted to irrigate the land. The total water lift which was required at the Grand Coulee dam was 630ft. More than half of the lift, approximately 350ft, was accomplished by the building of Grand Coulee dam, which now retains water in a 151-mile lake extending to Canada. The final lift of 280ft is now being obtained by pumping. An aerial view of the pumping plant and the storage works is shown in the illustration overleaf. Each of the 65,000 h.p. synchronous pumping motors is 25ft high, has a circumference of approximately 100ft, and weighs more than 300 tons. It is electrically connected to a 108MW generator in the Grand Coulee dam power station downstream from the pumping plant. The pumps are vertical-shaft, single-impeller, centrifugal pumps, each having a designed capacity of 1350 cusecs at a 310ft head. Their maximum capacity is 1600 cusecs at a 280ft head. By means of twelve steel pipes, each 12ft in diameter, the water is being carried from the pumps to headworks, where a feeder canal receives the water on top of the hill. These twelve pipes can carry a flow almost as great as the average flow of the Colorado River at Hoover dam. The pumping plant, which houses the pumps and motors, is adjacent to and behind Grand Coulee dam. The wing dam, behind which the pumps are installed, was built in 1938–39 when the Grand Coulee dam was under construction. During the war the completion of the irrigation scheme had to be postponed to meet growing power demands. To-day, all of Grand Coulee's eighteen 108MW generating units are in operation, producing almost half of the hydro-electric power used in the Pacific North-West of the United States. Only a small part of this power

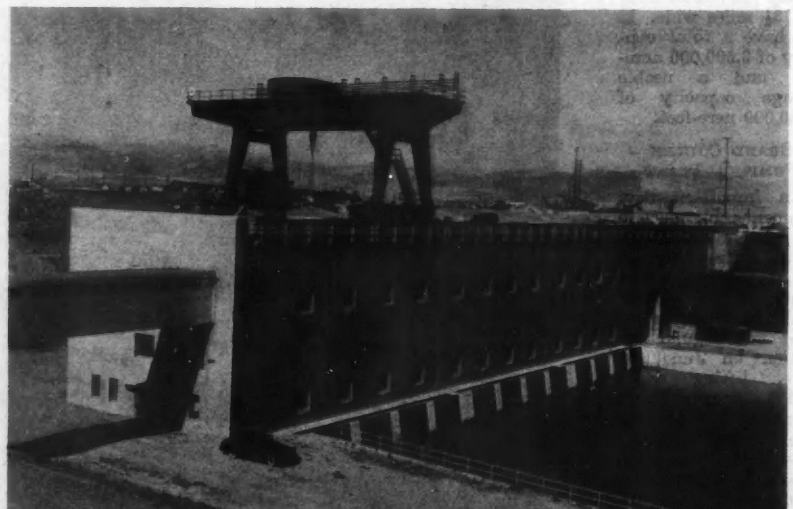
INSTALLATION OF SCROLL CASING—HUNGRY HORSE POWER STATION

GRAND COULEE PUMPING PLANT AND STORAGE WORKS

will be used for irrigation pumping, even under maximum development, most of it at a time of year when the river flow is high and the demand for power is low.

Tracy Pumping Plant

The Central Valley project, firm operation of the initial phase of which started last August, consists of an integrated system of dams, power stations, pumping plants and canals; it has been called the most comprehensive water resources development ever undertaken. Its major objective is to equalise the water resources of the great central basin of California by storing water at its northern end and transporting it to and from lands almost 500 miles to the south. The Tracy pumping plant is the main pumping station of the Central Valley project. The accompanying illustration shows the completed station, which is situated at the end of a canal 2 miles long connecting it to the Sacramento–San Joaquin River delta. The station installation comprises six 84in vertical-shaft, centrifugal pumps having a combined capacity of 4600 cusecs at the design lifting head of 197ft. The pumps are Y-connected, in pairs, to three discharge pipes of 15ft inside diameter. The pump rotors are each direct connected to the rotors of six vertical-shaft, 1·3kV, three-phase, 60 c/s a.c. synchronous motors. The motors rotate at 180 r.p.m., and each has a capacity of 22,500 h.p. Power for the operation of the Tracy pumping plant is obtained from the Shasta and Keswick power stations through a 230kV transmission line which extends along the east side of the Sacramento Valley.



Tracy Pumping Plant

Technical Reports

A Rapid Method of Analysis for Bituminous Road Materials. Road Note No. 10. Road Research Laboratory, D.S.I.R. London: H.M. Stationery Office. Price 1s.—When premature failure of a bituminous road surfacing occurs it is more frequently due to lack of compliance with the specified composition than to any other cause. The composition can only be reliably checked by analysis of the product as it leaves the tarmacadam or asphalt plant. One surfacing machine may need to be fed with over 200 tons per day, and high output is therefore demanded from modern mixing plant. If control is to be close and effective there is therefore a great need for a rapid method of analysis. The rapid method described in this report enables the tar or bitumen content and grading of a bituminous road mixture to be determined in one to two hours: the "carpet" type of mixture, which is in such great demand to-day, can be analysed in 30 minutes. These methods are said to give results of comparable accuracy to the British Standard methods.

A Graphical Method for Changing Scale

By H. FEALDMAN, M.A. (Cantab)

To the practising engineer the use of a graph is so greatly second nature that it is not realised how much the graph is an integral part of modern engineering practice. Both for the design engineer who, as he draws his bending moment diagrams and reads off his design factors, and for the engineer in the field as he watches his rate of contract progress or rate of production, hardly a day passes without reference being made to a graph of some sort.

Basically, a graph is one of many means of pictorially relating given sets of figures whether or not this relationship can be expressed mathematically. However, the graph differs from other methods in that it is plotted on a sound mathematical basis. For engineering purposes the Cartesian (or rectilinear) system of co-ordinates is almost universally adopted, to the detriment of a system such as polar co-ordinates. In practice, the major problem which the engineer has to face is that of scale.

When plotting two sets of quantities the problem of scale is relatively simple, the only factors to be correlated are the physical dimensions of the paper, the size of the superimposed

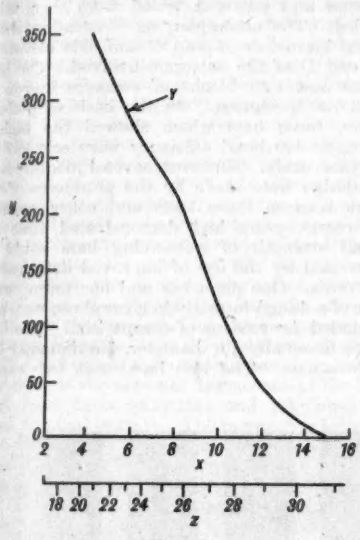


FIG. 1

graticule and the range of the quantities under consideration, which it is desired to plot. When a third variable is introduced the problem is somewhat complicated. There are two solutions of this problem. One is to plot "constant value lines" of this third quantity on the graph. One of the best-known examples of this type of graph is the Mollier diagram, with which every student of heat engines is familiar. The other solution, and the one which appeals most to the practical engineer, is to plot three graphs showing the relationship between each set of quantities taken in turn. This, of course, simplifies the problem of the scale to use, which is determined separately for each graph.

Frequently, especially in experimental work, it is required to plot the relationship between two sets of quantities when the relationship between both of these sets of quantities and a third set of quantities is known. Mathematically the problem may be stated thus:—If x, y and z are variables and the relationship between x and y and between x and z have either been produced on a graph or are known in other ways it is required to plot a graph of y against z. Alternatively, the problem may be considered to be that of changing the scale of x to that of the scale of z. Should the relationship be of a mathematical nature, then the problem may be solved in a theoretical manner. Unfortunately, in engineering practice the relationships are usually not of a mathematical nature, and recourse must be had to practical methods such as scaling off selected points and replotting. This method is subject to many inaccuracies and is exceedingly tiresome if many replots are required.

Such a problem arose recently when it was required in the course of an investigation to change the scale of the abscissæ of a large number of graphs, many of which were composed of "families" of curves. The difficulty in this task lay in the fact that the relationship between the two scales was of a somewhat

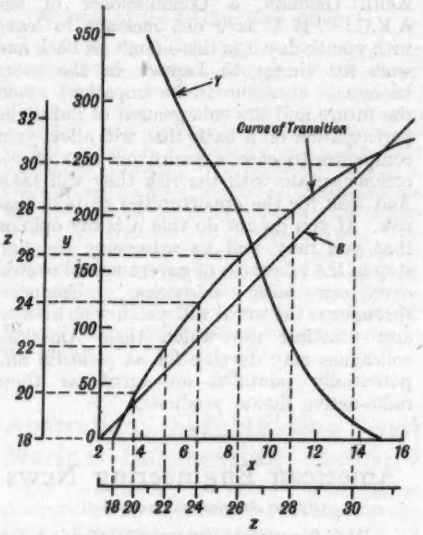


FIG. 2

arbitrary and non-linear character. No record of co-ordinates, nor any information beyond the new scale required, was available.

At first sight the task appeared exceedingly tedious, but the following graphical method was devised. Not only does this method reduce the time, but it is more accurate than scaling off and plotting. On test when twenty selected points were considered it was found that the average accuracy when these points were read off was to 0·3 per cent by the graphical method and to 0·8 per cent by the method of scaling off and replotting. The time required for the graphical method was some 40 per cent of the

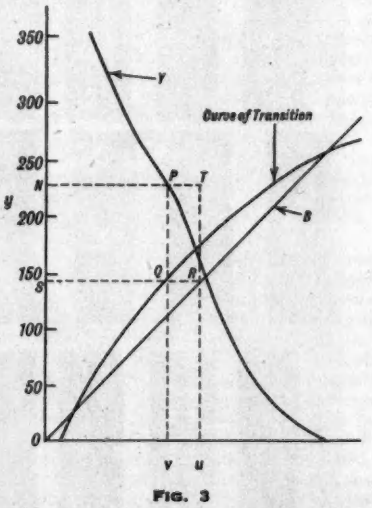


FIG. 3

time required for the scaling and replotting method. This method may be applied very easily to all similar problems.

In Fig. 1, curve Y is obtained by plotting the variable y as ordinate against the variable x as abscissa. It is required to replot the curve replacing x by the variable z as abscissa. The relationship between x and z is known and is shown by plotting z to the same scale as x at the bottom of Fig. 1.

The scale of the quantity z must now be determined. This scale may commence at 0 or at an intermediate value. In this particular case it was decided to commence it at 18. Set this scale off as ordinate. By plotting the points where similar values of z intersect a curve called the "curve of transition" may be obtained (Fig. 2). Next draw a line through the origin at 45 deg. to the axes of co-ordinates (labelled B in Fig. 2).

Referring to Fig. 3, select any point P_1 (co-ordinates x_1, y_1). It is required to transfer them to (z_1, y_1). Produce PQ vertically until it intersects the curve of transition in Q. Draw QR horizontally so that it intersects the line B, in R. Next draw RT vertically until it meets the horizontal through P at T. The point T is the required point (z_1, y_1). The process is repeated to find points (z_2, y_2) and (z_3, y_3), &c., and the new curve Y_1 is drawn. The scale of z may now replace the scale of x as the abscissa. Care must be taken that this is the same as the scale previously drawn for constructional purposes on the ordinate (Fig. 4).

This method is extremely quick and simple to use in practice. It is found advantageous to select the points P_1, P_2, &c., where the horizontal lines of the graph paper (or co-ordinate grid) cut the curve Y. A great advantage of the method is that when it is required to transpose a family of curves only one construction for the curve of transition is required.

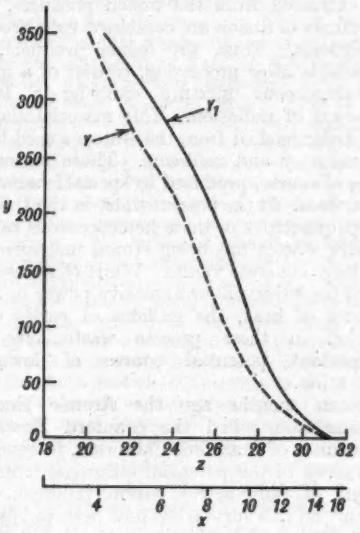


FIG. 4

The proof of the construction is as follows:—Referring to Fig. 3.

Owing to the construction of the curve of transition,

$$z_1 = VQ,$$

$$VQ = RU = SR \text{ (45 deg. line)},$$

But

$$SR = NT.$$

Therefore

$$NT = z_1.$$

But

$$TU = PV = ON = y_1.$$

Hence

T is the point (z_1, y_1).

INSTITUTE OF METALS' AWARDS.—The Council of the Institute of Metals has made the following awards of medals for 1952:—The Institute of Metals (Platinum) Medal to Mr. William Stanley Robinson, until recently president of the Consolidated Zinc Corporation, Ltd., in recognition of his outstanding services to the non-ferrous metal industries in developing the Australian zinc-lead industry and the British zinc industry; the Rosenhain Medal to Professor André Guinier, Conservatoire National des Arts et Métiers, Paris, in recognition of his outstanding contributions in the field of physical metallurgy, particularly in connection with precipitation phenomena, and the W. H. A. Robertson Medal to Mr. Cyril Ernest Davies, for his paper on "The Cold-Rolling of Non-Ferrous Metals in Sheet and Strip Form."

Industry and the Atom

(By Our American Correspondent)

In these days of material shortages there is one group of products which is in more than plentiful supply in the United States—fission products, the by-product radio-active materials resulting from the operation of nuclear chain reactors. The bulk of these by-products are, at present, being "manufactured" at the Hanford Works of the U.S. Atomic Energy Commission in the State of Washington, where plutonium is produced from uranium. The splitting of uranium 235 atoms during fission, it will be remembered, results in the formation of a series of isotopes which, in general, are radio-active and are within an atomic weight range of 72 to 162. They are isotopes of such common elements as iodine, cadmium, molybdenum, strontium and caesium, and also include isotopes of some of the rarer elements not commonly known or used. In the chemical process which follows fission and by which the plutonium is extracted from the fission products, the elements of fission are combined with process chemicals. Thus, the fission products, as available after processing, consist of a gross heterogeneous mixture emitting a large amount of radiation. This material should be distinguished from the isotopes used both in industry and medicine. Those materials are, of course, produced by special irradiation processes. At the present time, in the U.S.A., vast quantities of these heterogeneous radio-active wastes are being stored underground in large concrete vaults. While of no usefulness for industrial or explosive power or as a source of heat, the millions of curies contained in these process wastes are an important potential source of low-cost radiation.

Some months ago the Atomic Energy Commission asked the Stanford Research Institute, of Stanford, California, to conduct a survey of the potential industrial employment of radio-active fission products. A report on this survey has now been published and, broadly, the Institute has found that, once certain technical and economical problems are solved, many new uses for these by-products could be developed. The report suggests that present commercially feasible industrial uses for these wastes include the activation of phosphors for self-luminescent signs and markers; the employment as static eliminators for a variety of industrial processes; the reduction of starting voltage requirements in fluorescent light tubes and in process control instruments which incorporate a source of radiation. Under possible future uses, providing the technology can be developed, are listed industrial radiography; the cold sterilisation of drugs and foods; and portable low-level power sources. A number of prominent American industrial concerns have expressed interest in the setting up of pilot plant operations, particularly in the field of radiation sterilisation, as suitable fission products become available. In the opinion of the investigators, "the technological and marketing problems confronting the Atomic Energy Commission in making fission products available to industry are difficult, but not insurmountable."

These serious efforts to get industry interested in the use of fission products, follow earlier arrangements concluded between the Atomic Energy Commission and American industrial concerns regarding such developments as the manufacture of certain medical radio-active compounds and the design of reactors for power generation. They are representative of a genuine desire held by the administrators of the Commission to let "private enterprise" play as large and as important a part in the development of the industrial applications of atomic energy as the present security regulations will permit. This spirit, which is all the more welcome in view of the many contrary attitudes one finds in other Government departments on both sides of the Atlantic, was rather well expressed in an address to the recent annual meeting of the American Society of Mechanical Engineers by Mr. T. Keith Glennan, a Commissioner of the A.E.C.: "If I have one message to leave with you to-day it is this—don't sit back and wait for things to happen in the atom business. Continue to be impatient about the future and the enlargement of industrial participation on a basis that will allow your companies to earn a return on your efforts commensurate with the risk they will take. And look for the opportunities to take that risk. If you do not do this it is my opinion that you may well be witnessing the first step in the extension of governmental control over our basic industries." Engineers throughout the world will watch with interest any practical use which their American colleagues may develop for as plentiful and potentially powerful an agent as these radio-active fission products.

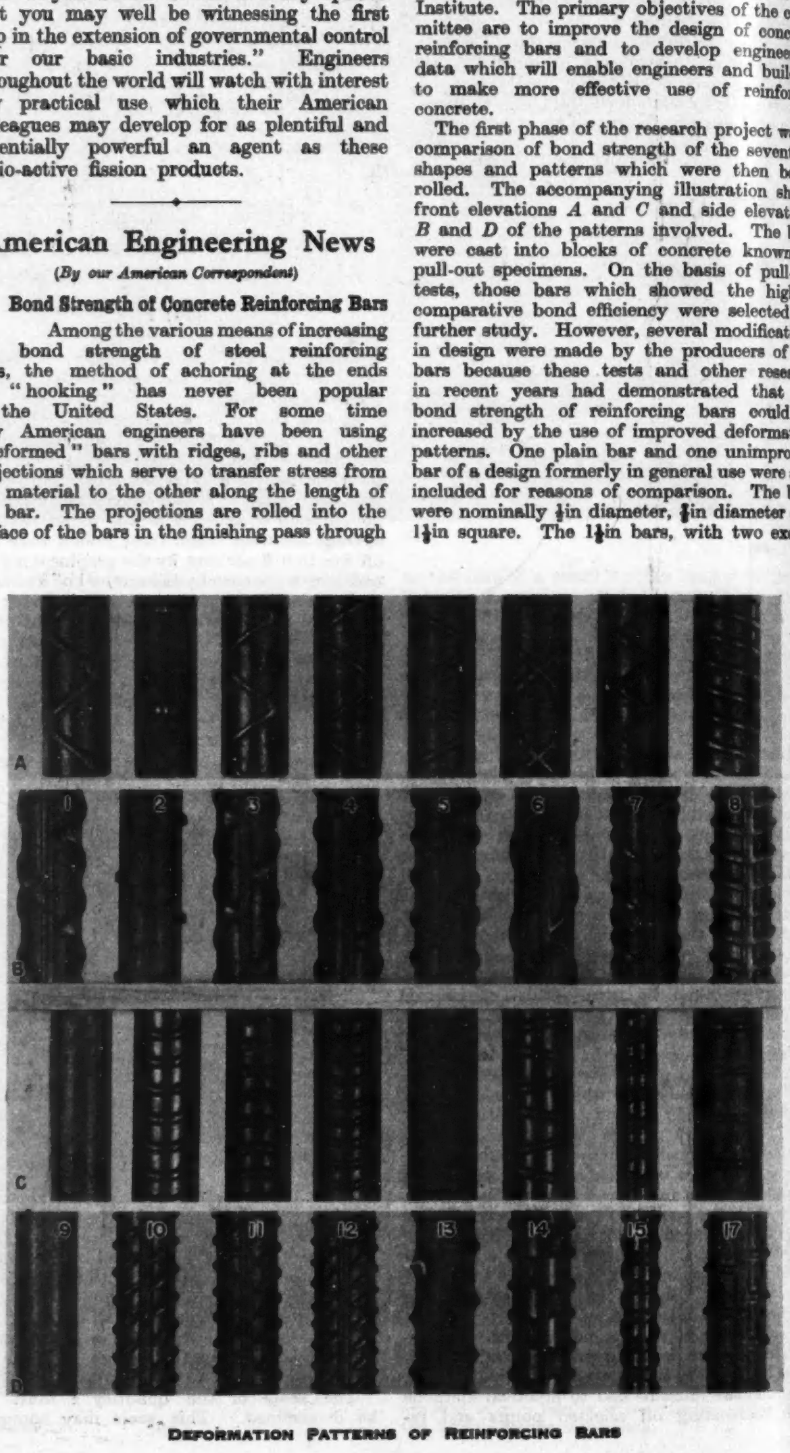
American Engineering News

(By our American Correspondents)

Bond Strength of Concrete Reinforcing Bars

Among the various means of increasing the bond strength of steel reinforcing bars, the method of achoring at the ends by "hooking" has never been popular in the United States. For some time now American engineers have been using "deformed" bars with ridges, ribs and other projections which serve to transfer stress from one material to the other along the length of the bar. The projections are rolled into the surface of the bars in the finishing pass through the rolling mill. Many different patterns have been developed, and, until recently, bars with the largest deformations were believed to provide the best bond. For many years there have been standard specifications in the United States covering the physical and chemical properties of both plain and deformed bars. Local building codes were set up to give the permissible bond stresses for both kinds of reinforcing members. However, there has, so far, been no definition of a deformed bar, nor have there been requirements for the deformations. Furthermore, little, if any, data had been available on which to base a scientific definition. Consequently, any bar with arranged projections, however ineffective, had come to be accepted as a deformed bar. In an effort to help clarify the situation, the American Iron and Steel Institute, in 1944, established a research fellowship at the National Bureau of Standards. The fellowship is one of several sponsored at various institutions by the Committee on Reinforced Concrete Research of the Institute. The primary objectives of the committee are to improve the design of concrete reinforcing bars and to develop engineering data which will enable engineers and builders to make more effective use of reinforced concrete.

The first phase of the research project was a comparison of bond strength of the seventeen shapes and patterns which were then being rolled. The accompanying illustration shows front elevations *A* and *C* and side elevations *B* and *D* of the patterns involved. The bars were cast into blocks of concrete known as pull-out specimens. On the basis of pull-out tests, those bars which showed the highest comparative bond efficiency were selected for further study. However, several modifications in design were made by the producers of the bars because these tests and other research in recent years had demonstrated that the bond strength of reinforcing bars could be increased by the use of improved deformation patterns. One plain bar and one unimproved bar of a design formerly in general use were also included for reasons of comparison. The bars were nominally ½in diameter, ⅝in diameter and 1¼in square. The 1¼in bars, with two excep-



Deformation Patterns of Reinforcing Bars

tions, were round in cross section having areas equal to 1¼in square bars. Whereas ordinary pull-out tests were used in the early work for comparing the bars, a more elaborate test was devised for the final evaluation of bond strength. Beams 6ft 6in long, 8in wide and 1ft 6in high were cast, with bars embedded at a distance of 2in from the edge of the beam. Half of the beams were cast with the reinforcing bars at the bottom of the mould and half with the bars at the top. The beams with the bars embedded near the top were subsequently turned upside down for testing. At the same time, pull-out specimens 8in by 9in in cross section, and 8in, 12in and 16in long, respectively, were prepared so that a direct comparison could be made between the pull-out tests and the beam tests. Two notches, 6in long and 3in wide, were placed near the end of each beam. A short length of the reinforcing bar, on which measurements could be made, was thus left exposed. Dial gauges were attached to the bar to give a direct measurement of strain and slippage of the bar as a load was applied to the beam. The beams were tested in a 400,000 lb hydraulic testing machine. In general, the beams were found to fail in bond. The pull-out specimens failed by splitting of the concrete, except when a plain bar was used.

Shortly after this work was started, and on the basis of the preliminary pull-out tests, a "tentative specification for minimum requirements for the deformations of deformed steel bars for concrete reinforcements" was adopted by the American Society for Testing Materials. This made it possible to include bars designed according to the tentative specification in the study. Data from the tests indicated two desirable revisions, and the specifications involved were adopted recently as an A.S.T.M. standard, designated A305–49. The standard sets forth requirements and methods of measurement and specifies the number of test specimens to be taken and the basis for rejection. Definite requirements are included for the angle of deformation, the average spacing of deformations on each side of the bar, the average height of deformation and the maximum gap between the ends of the deformations. Spacing, height and gap of deformations are given as percentages of the nominal dimensions of the bar, and have been computed and tabulated for each nominal bar size. The correlation between the results of the beam and the pull-out tests was such as to indicate that pull-out tests can give reliable estimates of the bonding efficiency of deformed reinforcing bars. Although the data obtained from the two corresponding specimens did not always evaluate the bars in the same order, the differences in ratings were usually too small to be of practical significance; moreover, the relations between load and slip were of similar form, and the general behaviour of the bars was similar in the two kinds of tests. The plain bar gave the least bond; the old deformed bar gave a somewhat higher bond, and the remainder of the bars gave still higher values, with those meeting A.S.T.M. Specification A305–49 showing the highest bond. The superior performance of the improved bars was most marked when the conditions were least favourable for obtaining a strong bond, i.e., with the bars in top position as the specimens were cast. As a result of these tests, the American Concrete Institute has now revised the provisions of its Standard Building Code for Reinforced Concrete. The allowable bond stresses of the improved types of deformed bars have been increased by 100 per cent and those of plain bars have been reduced. All bars not conforming to A.S.T.M. Specification A305–49 are now classed as plain bars. Another result of the work, particularly important in view of the present steel shortage, is the fact that only five designs of bars, as against the original seventeen, are now in commercial production. The research work of the American Iron and Steel Institute is continuing under the direction of Arthur P. Clark, who has headed the project since it was established. Studies have now been completed of factors which control the resistance of reinforced concrete to diagonal tension. Work is in progress on the measurement of cracks in reinforced concrete flexural members, relating the width of crack to the stress in the reinforcing bar and to other contributing factors.

Research work on the bond strength of reinforcing rods with corrugated surfaces was also carried out in Sweden during the war years. This work resulted in the adoption, in Sweden, of a standardised corrugated rod. A description of the properties of these standard rods was given in THE ENGINEER of September 28th last.

Closure of the Golden Gate Bridge

On December 1st, a storm involving winds of 72 m.p.h. caused the closure for almost three hours of the Golden Gate Bridge, at San Francisco, which has a suspended centre span of 4200ft. The wind induced vertical vibrations of the bridge deck having a maximum total amplitude of 85in, the greatest vibration recorded since a set of ten recording instruments was installed on the bridge following the failure of the Tacoma Narrows Bridge in 1941. The mode of vibration observed was the simplest possible for a bridge span, with the maximum displacement occurring at the centre and the motion being almost perfectly symmetrical. The vibrations did not result in any damage to the bridge.

Australian Shipbuilding and Marine Engineering Industry

THE expansion of heavy industries in Australia and the construction of ships for the Royal Australian Navy since the war have opened up encouraging prospects for the shipbuilding and marine engineering industry in that country. Those industries were at a very low ebb in 1939. Between the two world wars a few naval vessels were constructed at the Cockatoo Docks and Engineering Company's yard at Sydney, including the old seaplane carrier "Albatross" and one or two destroyers and sloops. But, in 1939, apart from small coasters and harbour craft, not a single ship had been laid down in any other yard in the Commonwealth since the termination of the 1914–18 war. Only Cockatoo dockyard had maintained a nucleus of highly qualified drawing-office staff and workmen trained in naval shipbuilding and engineering work. But on the outbreak of war a large expansion of the shipbuilding industry was at once put in hand. Provision was made for the construction of a number of the smaller types of naval vessels—in addition to the two "Tribal" class destroyers then building at Cockatoo yard—and of several cargo freighters of up to 10,000 tons deadweight, as soon as manpower and equipment became available. This entailed re-equipping old yards, which, between the wars, had turned over to other industries, and the construction of slipways, drydocks and, in one instance, of a completely new shipyard at Whyalla in South Australia.

To equip these yards satisfactorily many new machine tools and a great deal of shipyard and engineering equipment had to be obtained, and although some of the items were acquired from Great Britain, Canada and the United States, much of the new material was manufactured in Australia. Prior to the war, a careful survey of the potentialities of the Australian engineering and electrical industries had been carried out and this did much to ensure that as far as possible the equipment required to fit out the ships should be made in Australia, and that the call on overseas supplies should be reduced to a minimum. A number of engineering firms were at once turned over to the manufacture of this special equipment to meet the requirements of the building programme as it developed, skilled personnel being directed by the Government as required. These measures resulted in the completion of several minesweepers, frigates and auxiliary ships for the Royal Australian and Indian Navies, and of a number of cargo vessels for the local shipping lines, whose resources were taxed to the utmost by the war. The two destroyers building at Cockatoo yard were completed, bus repairs to damaged men-of-war from the Pacific operations area precluded any further building of vessels of this kind.

By the end of the war it had become clear that the shipbuilding industry, which had been built up at great cost, was of considerable strategic importance to Australia, and the Government decided to retain control of all merchant ships constructed in that country and to run them, with the co-operation of the principal shipping companies, as a Government shipping line for coastal trade. The old shipbuilding yards—now re-equipped and reorganised—were kept fully employed by a new building programme of merchant ships ordered by the Commonwealth Shipping Board to replace war losses and to meet the large new demand for ships resulting from increased trade. Concurrently the Broken Hill Proprietary Company, which was soon to have an additional source of iron ore supply from Cockatoo Island, Yampi Sound, on the north-west coast, laid down four new ore carriers of 12,500 tons deadweight at its newly completed shipyard at Whyalla, South Australia, for the transport of iron ore to its steel works at Newcastle and Port Kembla on the east coast.

Finally, the Government decided on a destroyer-building programme at the Cockatoo yard and at the Navy Yard at Williamstown, Victoria, three modern destroyers being laid down at each of these yards. Two of the destroyers have now been completed and have joined the Fleet and the remainder are in an advanced stage of construction. Approval has also been given recently to lay down six fast anti-submarine frigates, three at each yard. Apart from certain specialised equipment the whole of the hulls and machinery for both destroyers and anti-submarine frigates are being built in Australia. There are also a number of smaller warships under construction in other yards. The growth of the Royal Australian Navy since the war has, indeed, been remarkable, and it is the Government's intention to provide for a fleet of 116 warships in all, including two aircraft carriers (constructed in Great Britain), nine destroyers, twenty-five frigates and thirty-two minesweepers.

Given the availability of men and materials, the Australian shipbuilding potential is now about 75,000 tons deadweight per annum. The principal yards are at Brisbane, Queensland; at Newcastle and Sydney, in New South Wales, and at Whyalla, in South Australia. All these are commercial yards, capable of building ships up to 12,500 tons. The Naval Yard at Williamstown, Victoria, is primarily a small shipyard, although vessels of 10,000 tons deadweight have been built there. There is also a small shipyard at Maryborough, in Queensland. Suitable plant and lay-out are available both at the Cockatoo yard and the Williamstown naval yard for building ships of all-welded construction, and the two yards have concentrated on this class of work for the past two years. All Australian shipyards, other than Williamstown, have marine engineering capacity for constructing the main engines and boilers of merchant ships up to 12,500 tons, but the main machinery and boilers of up to 30,000 s.h.p. per set for destroyers have up to date been constructed only at the Cockatoo yard. The cutting of the larger sizes of main gearing can be done only at the Government-owned gear-cutting annex at Bendigo, Victoria, and at the B.H.P.'s yard at Whyalla. Electric generating machinery and motors are now being manufactured in increasing numbers in Australia, but the diesel engine manufacturing capacity is still very limited.

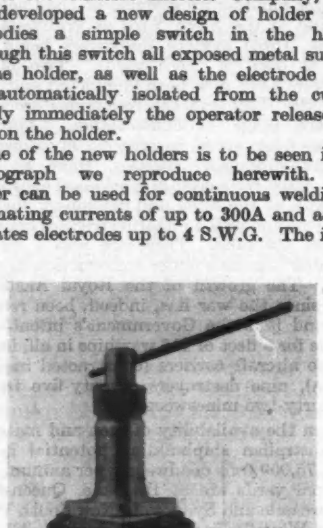
The main problem at the moment, however, is the shortage of skilled manpower, which is felt in almost every trade in Australia, and is particularly acute in the shipbuilding and marine engineering industry owing to the drift back of men to their former work following the removal of wartime manpower controls. In spite of high wages there is a serious shortage of ship and engine draughtsmen, boilermakers and shipwrights. Senior draughtsmen earn about £A1000 (£800 English) per annum, while skilled tradesmen earn £A13–£14 for a standard forty-hour week, which is increased to between

£A15 to £20, working normal overtime. Yard officials are paid at a correspondingly high rate, the salary, for example, of the works manager, Williamstown Naval Dockyard, Victoria—a post which is now vacant—being £A1592–£1778 per annum. The Royal Australian Navy is also very short of engineer officers (both mechanical and aeronautical) and electrical officers, and offers a first-rate career to young Englishmen who hold a University Degree of Bachelor of Science (or acceptable equivalent), and who wish to make their home in Australia. Starting as a lieutenant at £A793 19s. 6d., they rise to £A1843 5s. after ten years as a captain, in addition to marriage allowance and a free passage to Australia for wife and family.

Electrode Holder for A.C. Welding

THE use of a completely insulated electrode holder with alternating current welding equipment, although it obviates some of the risks of shock to an operator, still leaves an element of danger when changing electrodes. For this reason the General Electric Company, Ltd., has developed a new design of holder which embodies a simple switch in the handle. Through this switch all exposed metal surfaces of the holder, as well as the electrode itself, are automatically isolated from the current supply immediately the operator releases his grip on the holder.

One of the new holders is to be seen in the photograph we reproduce herewith. The holder can be used for continuous welding at alternating currents of up to 300A and accommodates electrodes up to 4 S.W.G. The isolat-



INSULATED ELECTRODE HOLDER

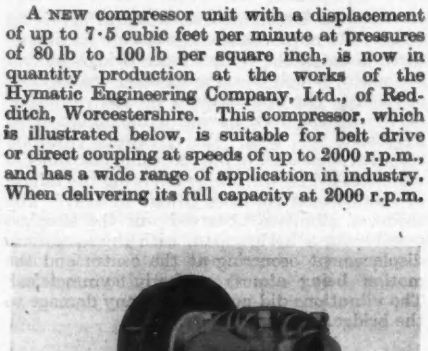
ing contacts are housed in the handle and are operated by depressing a lightly loaded spring lever arranged parallel with the body of the holder. Although the welding current is usually broken at the arc the switch can be used for this duty so it must be capable of breaking the full welding current without severe arcing at the contacts. The makers state that experience in service has shown that the switch will interrupt this highly reactive current hundreds of times without failure.

In order to prevent the safety mechanism from being deliberately put out of action by tying the lever in the on position, the design is such that electrodes can be inserted and withdrawn only when the switch is in the safety position. A central plunger is used to hold the electrode in position and this plunger must first be retracted by the outward movement of the switch lever before an electrode can be replaced. This outward movement of the lever ensures that the contacts have separated to isolate the holder and electrode.

The design of the holder ensures cool operating conditions, long working life, simplicity of dismantling without the use of special tools and ease of renewal of worn parts. The holder weighs only 24 oz and is well balanced to reduce operator fatigue.

A Small Air Compressor

A NEW compressor unit with a displacement of up to 7·5 cubic feet per minute at pressures of 80 lb to 100 lb per square inch, is now in quantity production at the works of the Hymatic Engineering Company, Ltd., of Redditch, Worcestershire. This compressor, which is illustrated below, is suitable for belt drive or direct coupling at speeds of up to 2000 r.p.m., and has a wide range of application in industry. When delivering its full capacity at 2000 r.p.m.



SMALL AIR COMPRESSOR

it requires 1·34 h.p., or at 1500 r.p.m. for air delivery at 80 lb per square inch a 1 h.p. drive.

The unit consists basically of a single-stage, air-cooled, 6·56 cubic inch capacity compressor, with a 1·97in bore, 2·16in stroke. It is pedestal mounted on a totally enclosed cast iron crankcase. The drive pulley is designed to pass a stream of cooling air over the unit.

The cylinder has a cast iron liner inside its finned aluminium barrel, and a light alloy piston is fitted with one scraper and two compression rings. The forged steel connecting-rod has roller bearings in the big-end and a phosphor-bronze bush in the small-end. To give smooth running the copper brazed overhung crankshaft is fitted with an integral balance weight and is carried in a wrapped bush main bearing. Low-lift plate disc valves with large air passages give low air speeds and the construction is such that the suction and delivery valve assembly can be easily removed as a single unit, to facilitate maintenance or replacement.

Splash lubrication provides an adequate oil supply to the cylinder, piston, big-end and main bearings, and oil consumption is stated to be 1 pint for 250 hours of running time.

AMERICAN STEEL PRODUCTION CAPACITY.—Reports made by the American Iron and Steel Institute indicate that steel production capacity in the U.S.A. is now put at 108,587,670 tons annually, or about 4,300,000 tons more than at this time last year. It is also stated that, in the first week of this year steel output was 102 per cent of capacity, compared with 98·2 per cent in the corresponding week of 1951.

French Engineering News

(From our French Correspondent)

The French National Assembly has authorised £9 million to be granted as credit to the shipbuilding industry as a whole and another £11 million to be used for the construction of new ships to replace those which have been lost to the merchant fleet through Government requisitioning.

The first sum will be used for new building, and of it some £7 million will be for new merchant ships, £1·5 million on repairs and the construction of trawlers, and £500,000 for foreign orders.

Foreign orders are not heavy, but there has been an increase in the number of inquiries from Chile, Pakistan, the Soviet Union, America and Turkey. The Americans have four tankers of 31,500 tons on order from France and a fifth is now being negotiated. There are also some Turkish orders to be met.

To meet current orders a serious problem faces the industry, however, owing to the fact that no more than half the steel plate required will be obtainable. It is hoped, however, that the shipbuilders will receive an allocation of 10,000 tons of sheet steel per month throughout 1952. If these supplies are forthcoming then the position should be easier.

* * *

A new power station which has recently been completed at Herserange uses gas from the coking plants of Longwy and three other plants for steam generating purposes.

The construction of the plant has taken six years and the work has entailed the construction of a new railway line and a gasholder of 50,000 cubic metres capacity. Gas is brought to the plant by two mains from the Longwy mills and from Chiers.

The generating plant comprises three turbo-alternators of 40,000kWh capacity. A reserve of water and gas will enable the plant to remain in operation for seventy-two hours if the gas supply fails.

* * *

The Sté des Ateliers et Chantiers de France is rebuilding its dockyard facilities in order to meet orders for several large tankers. The most important of these is for the "Caledonian." Several other large tankers will be built when the modifications are completed.

* * *

Despite the war in Indo-China, construction goes on and the country is being developed as far as possible. A new hydro-electric plant has just been completed at Dalat. It includes a 1400kW set, which will supply a 22kV network. The reservoir holds 60 million cubic metres of water and the scheme has a head of 800m.

* * *

The development of French civil aviation has brought to light certain difficulties the French are having designing aeroplanes for their lines. At the moment American aeroplanes are being extensively used. It is learned, for example, that the "Armagnac," which was intended for the North Atlantic service, has an insufficient range and therefore had to be abandoned. Altogether some ten different projects were examined, but in the face of heavy foreign competition it was decided to abandon them all. None were absolutely satisfactory.

It is now learned that 40-ton to 80-ton machines are being studied, but the problem of spare parts is holding up progress. As France has not built commercial aeroplanes for some time, no plants, under present circumstances, are in a position to produce the spare parts which a fleet of aeroplanes would constantly demand.

The most interesting prototype is the "Deux Ponts." Its performance is said to be superior to the American "D.C.6" machine, and once the rearmament programme permits production, France intends trying to export these aeroplanes in large numbers. Work is going ahead on two jet prototypes to be used on the Paris-London and Paris-Casablanca services. These machines are being studied by three different constructors. Another interesting development is the construction of a forty-seat helicopter.

Industrial and Labour Notes

Changes in Wage Rates

Changes in wage rates which were reported to the Ministry of Labour as coming into operation in December last resulted in an aggregate increase of approximately £565,000 in the weekly full-time wages of 1,200,000 workpeople. Among those affected by the increases were workers in the coal mining, iron and steel, heavy chemicals and light castings industries, and in H.M. Dockyards and Government industrial establishments. In the coal mining industry there were increases to the national minimum weekly wage of 13s. 6d. for underground workers and 11s. 6d. for surface workers, which were retrospective to November 22nd. Adult male workers in H.M. Dockyards and Admiralty establishments and in other Government engineering establishments received an increase of 11s. a week, retrospective to November 23rd.

Statistics which are compiled by the Ministry of Labour show that in 1951 changes in wage rates resulted in 12,239,000 workpeople receiving increases which aggregated approximately £6,546,700 a week. No decreases in wage rates were recorded during last year. The Ministry of Labour says that in 1951 the number of workers participating in increases and the total amount of those increases were the largest recorded in any year, the weekly rates, on average, having increased by 10½ per cent. It was the largest annual increase since the beginning of the current index of weekly wage rates based on June 1947=100, comparative figures being 4 per cent in 1950, from 1½ to 2 per cent in 1949, and 4 per cent in 1948. At the end of December, 1951, the index number for all workers was 126, compared with 114 at the end of 1950, 109 at the end of 1949 and 107 at the end of 1948. A more detailed examination of the Ministry's figures shows that in the groups of industries classified as engineering, shipbuilding, electrical goods, vehicles, and metal goods "not elsewhere specified," changes in wage rates last year meant an aggregate weekly increase of £1,320,100 for 2,414,000 people. During 1950, in those industry groups, 1,835,000 workers received increases totalling £828,500 a week.

It should be noted that, in all cases, the figures relate to wage earners and not to clerical or other salaried workers. They are based on the rates of wages for a full week and do not take account of variations in actual earnings arising from other factors, such as overtime or time lost. Furthermore, the changes in wage rates referred to are mainly those arranged by organisations of employers and workers. Changes arranged by individual employers and those affecting unorganised groups of workpeople are not generally reported to the Ministry.

The Steel Distribution Scheme

The Minister of Supply has made the Iron and Steel Distribution (Amendment No. 1) Order, 1952, authorising some adjustments in the iron and steel distribution scheme, which came into operation on February 4th.

The Order permits consumers to use stock held at the close of February 3rd for a purpose for which they possess a control authorisation, and holders of control authorisations may send material out on loan to be worked up for them. This amendment to the original scheme is designed to cover the "free-issue contract" customary in some trades for outside processing of material. Two new items—wire rod reinforcement fabric mesh and wire reinforcement mesh—have been added to the list of controlled forms of steel. The list of "small quantities exemptions" has been extended to permit the purchase, without licence, of 5 cwt a month of those items, and also 1 ton a month of "large spring" steel.

The Ministry of Supply has also announced that, as from April 1st, the separate allocation of non-alloy steel sheet will be abandoned, and that thereafter such steel sheet will be merged, for allocation purposes, in general non-alloy steel. Consumers will be free to decide for themselves, within their total authorised tonnage, how much they wish to order in the form of non-alloy sheet steel, and how much in the form of other non-alloy steel (other than tinplate, terneplate and blackplate, which will remain subject to separate allocation). Outstanding sheet allocations on forms M (sheets) will still be valid, with their legal requirements unchanged.

Non-Ferrous Metals

The Ministry of Materials has announced price changes for lead and virgin magnesium, which took effect as from February 1st. The price of imported good soft pig lead has been reduced from £175 to £170 per ton, delivered consumers' works. The price of virgin magnesium in ingot form has been increased from 2s. 4½d. to 2s. 10½d. a lb, delivered consumers' works.

The Ministry has also stated that, in order to facilitate the pricing of export orders, a supplementary method of pricing orders for copper, lead and zinc came into effect on January 31st. Orders may now be placed on the Directorate of Non-Ferrous Metals, 20, Albert Street, Rugby, by telegram, and provided telegrams are handed in to the Post Office not later than 2 p.m., the orders they contain are priced at the figure ruling on the day of despatch of the telegram. A licence continues to be necessary before a sales contract can be completed and the amounts licensed are limited to the quotas announced from time to time and notified to individual firms. All orders placed by telegram must be confirmed by letter, with the necessary supporting documents, and no steps will be taken to supply the metal until such a written confirmation is received. Telegraphic orders handed in to the Post Office after 2 p.m. are priced at the figure ruling on the day following and orders placed by letter continue to be priced on the day following the day of posting.

Index of Industrial Production

The index number of industrial production (1946=100), which is prepared by the central statistical office of the Treasury, has been estimated provisionally, for all industries, at 153 for November last, compared with 151 for October. In October and November, 1950, the index numbers were 152 and 153, respectively.

Taking the manufacturing industries alone, the index number for last November was 158, compared with 156 for October, and 159 for November, 1950. The Treasury says that, on the basis of information so far received, the index number for all industries for December, 1951, is likely to be 137 or 138, making the estimate for the whole of last year equal to 144, compared with 140 for 1950. This represents an increase of about 3 per cent, against an increase of 8½ per cent in 1950 over 1949.

Trade Disputes

During the month of December, there were in progress in the United Kingdom eighty-one stoppages of work, which arose from industrial disputes. They involved, directly and indirectly, 12,300 workers, and caused an aggregate loss during the month of 40,000 working days.

Stoppages of work through industrial disputes in the United Kingdom, reported to the Ministry of Labour as beginning in 1951, numbered 1719, the total number of workers involved being 379,000 and the aggregate number of working days lost being 1,692,000. In the preceding year there were 1339 stoppages of work reported, involving 303,000 workpeople and resulting in a loss of 1,389,000 working days. In the engineering industries last year there were eighty-two stoppages of work reported. In them 25,600 workers were concerned and the number of working days lost was 137.000.

According to the *Ministry of Labour Gazette* more than one-third of the aggregate loss of time through stoppages in 1951 occurred in the transport industry, principally amongst dock workers. The aggregate number of working days lost was 601,000. The coal-mining industry accounted for approximately one-fifth of the working days lost last year, although there was only one stoppage of considerable size. It affected a large number of collieries in Glamorganshire during the last three weeks of June and was in sympathy with workers whom it was proposed to transfer to another colliery as they had become redundant owing to the closing of part of the workings. Altogether, about 12,000 workers were involved in this stoppage and about 90,000 working days were lost. Another stoppage, last year, which meant a loss of some 60,000 working days, was that of more than 2000 workers in the electricity supply industry in London and the home counties. It began in mid-February and lasted till mid-April, and was caused through the suspension of a member of the Electrical Trades Union for refusing to work with an electrician's mate who was a member of another union.

Industrial Safety

The adjournment debate in the House of Commons on Monday last was concerned with the subject of industrial safety. Mr. Barnett Janner, who raised the matter, said that in industry generally the wastage of life and limb through accidents could be prevented. He asked the Government to show clearly that it was prepared to give every support to the efforts that were being made to that end.

Winding up the debate, the Parliamentary Secretary to the Ministry of Labour, Sir Peter Bennett, pointed out that the prevention of industrial accidents was really primarily a matter for employers and employed. He agreed that governments and other bodies could help but, he said, the observance of statutory regulations, even accompanied by an increase in the number of factory inspectors, would not solve the problem. A great many of the accidents which occurred, Sir Peter suggested, were not due to the familiarity that breeds contempt but to familiarity that breeds carelessness. Factory inspectors always advised that special safety officers and joint safety committees should be appointed wherever possible, but the Ministry of Labour felt that it was no use making the appointment of such committees a statutory matter; people must be encouraged to act voluntarily.

Sir Peter went on to say that a suggestion had again been made to set up a Government-sponsored committee to examine the question of industrial safety. The National Joint Advisory Council, however, had reached the conclusion that there was already adequate machinery, that the setting up of an additional committee would not be a good move, and that it would, in fact, be a waste of time and energy. Sir Peter added that he would not grudge any waste of time if it would help. What was really needed, however, was an intensification of existing efforts, making everybody who had to do with the running of industry feel that the safety of workers was a personal matter; not a matter to be treated just as ordinary day-to-day work, but a duty, to ensure that safety measures were kept up to date. Sir Peter assured the House that the points made during the debate would be carefully studied. He agreed that the waste through industrial accidents was enormous and that it could be reduced. It was the Government's duty to do all it could to that end, but its work would be successful only if individuals in factories could be made to understand their personal responsibilities.

Notes and Memoranda

Rail and Road

IMPROVEMENTS AT EUSTON.—In the improvements being carried out by British Railways at Euston platform No. 6, the oldest main line platform in London is being re-roofed, as well as platforms Nos. 8, 9 and 10. The greater part of the work on No. 6 platform, which has been completed, has involved the provision of 550 square yards of glazing. On platforms Nos. 8, 9 and 10, just started, the whole of the existing covering will be removed and replaced with large section corrugated asbestos sheeting and patent glazing, the total area of roof being 4100 square yards, approximately half of which will be glazing.

MOTOR EXPORTS.—The Society of Motor Manufacturers and Traders, reviewing the motor industry's activities in 1951, has recently stated that the exports of the industry brought in overseas exchange to the value of £317 million. Nearly 369,000 cars (77 per cent of total output for the year), worth just over £119 million, and 137,000 commercial vehicles (53 per cent of output), worth more than £69 million, were shipped to all parts of the world. For both classes of vehicle the values recorded were greater than those for any previous year's shipments. Consignments of wheeled agricultural tractors for 1951 created a new record both in volume and value with over 112,500 units at £41 million, compared with 84,000 at less than £30 million in 1950.

DIESEL LOCOMOTIVE FOR RHODESIA.—A special 300 h.p. diesel locomotive with four-speed mechanical transmission has been built by the Hunslet Engine Company, Ltd., for hauling 700/800-ton copper ore trains on the level in the extensive mining belt of Rhodesia. In a regular duty repeated each shift the locomotive will be used to haul loads of 170 tons up a line with a gradient of 1 in 38 for three-quarters of a mile, and with 180ft radius curves. The locomotive weighs 37 tons and has a maximum axle load of 12¼ tons, its height being 11ft 7in and overall width 8ft 3in. The rail gauge is the Rhodesian standard of 3ft 6in and the 3ft 9in wheels of the engine are spread over a wheel base of 9ft—short enough for curves of 125ft radius to be traversed. The oil engine runs at 900 r.p.m., and the transmission, comprising friction main clutch and preselective gearbox, gives track speeds of 4½, 6½, 10½, and 16½ m.p.h. Tractive effort on bottom gear step is 16,300 lb. on site, which is more than 6000ft above sea level.

Miscellanea

THE SWISS INDUSTRIES FAIR.—The thirty-sixth Swiss Industries Fair will be held at Basle from April 19th to 29th. It is announced that more than 2000 firms will exhibit. Full particulars of the Fair can be obtained from the Economic Division of the Swiss Legation, 18, Montague Place, Bryanston Square, London, W.1.

THE LATE MR. W. G. GROOCOCK.—We record with regret the death of Mr. W. G. Groocock, which occurred at his home at Northampton, on January 25th, in his eighty-second year. Until his retirement in 1941, Mr. Groocock had been manager, for twenty years, of the Birmingham works of the British Thomson-Houston Company, Ltd.

I.MECH.E. SUMMER MEETING.—The summer meeting of the Institution of Mechanical Engineers is to be held at Bristol on Tuesday, Wednesday and Thursday, June 17th, 18th and 19th. Professor J. L. M. Morrison, D.Sc., is chairman of the executive committee responsible for the local arrangements, and Mr. G. H. Beauchamp and Mr. J. G. Remington are the joint honorary secretaries.

TABULAR SUMMARY OF CIVIL ENGINEERING CONTRACTS.—In the edition of the *Tabular Summary of Civil Engineering Contracts*, which was published with our issue of January 25th last, a mistake occurs on pages 49 and 50, in the section entitled "Water Supply." The consulting engineers for the Coventry Corporation's River Severn scheme are given as Messrs. Binnie, Deacon and Gourley; in fact, Messrs. Binnie, Deacon and Gourley are joint consulting engineers for the scheme, with Messrs. Herbert Lapworth Partners.

THE INSTITUTE OF REFRIGERATION DINNER.—Some 400 members and guests attended the fifty-second anniversary banquet of the Institute of Refrigeration, which was held in London on Wednesday, January 30th. The president, Viscount Bruce of Melbourne, in replying to a toast of "The Institute," proposed by Dr. Charles Hill, paid tribute to the support received from the Ministry of Food, and spoke of the valuable work done by the refrigeration industry in connection with the preparation and distribution of food. In the course of his remarks proposing a toast to "Science and Industry," Sir Thomas White pointed out that co-operation between science and industry had brought about advances in refrigeration which had made possible the transport of meat and other foodstuffs from Australia to this country. Responding to this toast, Sir Samuel Beale said that a greater appreciation of the problems of industry by Government bodies was still badly needed, particularly where extensive changes in production programmes were involved. Sir Charles Darwin then spoke of the low-temperature group of the Physical Society and suggested that members of the Institute should attend its meetings and put forward their particular problems.

THE ENGINEERING CENTRE.—In response to many requests which it has received, the Engineering Centre, 351, Sauchiehall Street, Glasgow, C.2, has arranged office accommodation for a limited number of agents or representatives of engineering firms. An area of approximately 1000 square feet is being furnished with tables, desks, private lockers and telephone booths. The total number of participants will be limited to about twenty. The facilities offered will include the use of the Centre's telephone numbers and address, certain typewriting services, and the use of the catalogue library and information service.

WAKEFIELD (NEW) GENERATING STATION.—The British Electricity Authority has received the consent of the Ministry of Fuel and Power to the establishment of a new power station to be known as the Wakefield (New) generating station at Wakefield, Yorkshire, and to the extension of Dalmarnock generating station, Glasgow. The Wakefield (New) station, which will stand on a site of approximately 126 acres, will have a capacity of 240 MW, comprising four 60MW turbo-alternators and four boiler units, each having an evaporative capacity of 550,000 lb of steam an hour. The extension of the Dalmarnock station comprises two 60MW turbo-alternator sets and six boiler units, each of an evaporative capacity of 200,000 lb of steam an hour.

OBITUARY.—We have learned with regret of the recent death of Mr. John M. Baxter, M.I.Mech.E., chief mechanical engineer of Sir William Arrol and Co., Ltd., Bridgeton, Glasgow. Mr. Baxter, who was sixty-three, was a native of Broughty Ferry and received his early engineering training in the works of Urquhart Lindsay and Co., Ltd. After a period in the south, Mr. Baxter joined the staff of Sir William Arrol and Co., Ltd., and had been in that company's service for thirty-seven years. . . . We regret to record also the death of Mr. Frank Lonsdale, a director of the General Electric Company, Ltd., which occurred on January 27th. Mr. Lonsdale was sixty-eight and was formerly general manager of the G.E.C.'s Fraser and Chalmers Engineering Works, Erith.

KIRK O'SHOTTS TELEVISION TRANSMITTING STATION.—To bring television to Scotland as soon as possible, the B.B.C. proposes to put in service the low-power transmitter at the new television station at Kirk o'Shotts on Friday, March 14th, on an experimental basis. At 7.30 p.m., Mr. James Stuart, Secretary of State for Scotland, will open the service from the B.B.C. studios in Edinburgh, and the ceremony will be broadcast from Kirk o'Shotts. The General Post Office is installing a radio link to bring the television programmes to Scotland. It will also be experimental for the first few weeks and interruptions to the service may be necessary for adjustments. The Kirk o'Shotts station will carry the same programme as the existing stations at Alexandra Palace, Sutton Coldfield and Holme Moss, except that between 10 a.m. and 12 noon on weekdays during the first few weeks a still pattern ("Test Card C") will be broadcast instead of the morning film that is normally radiated by the other stations. It is expected that the low-power transmitter will provide satisfactory service over a considerable area of Central Scotland, including Edinburgh and Glasgow; but reception will be more liable to interference, particularly in fringe areas, than when the high-power transmitter comes into service.

Contracts

THE GENERAL ELECTRIC COMPANY, Ltd., has received orders from the Eagle Oil and Shipping Company, Ltd., and the Anglo-Saxon Petroleum Company, Ltd., for the electrical equipment for ten oil tankers. Each set of equipment includes two 550kW, 440V, three-phase turbo-alternators and one 200kW diesel-driven alternator. The turbines for seven sets are being supplied by Peter Brotherhood, Ltd., and three by the Fraser Chalmers Engineering Works of the General Electric Company, Ltd.

VICKERS-ARMSTRONGS, Ltd., announces that the Alvion Steamship Corporation, of Panama, has increased the order for one 32,000 tons deadweight oil tanker to a total of three ships. The dimensions of the vessels are 630ft length between perpendiculars by 85ft 6in breadth moulded by 46ft 8in depth, and the summer draught is 34ft 6in. The Naval Yard at Newcastle upon Tyne will build the hulls, and of the geared turbine machinery of 12,500 s.h.p., which will give a service speed of 15½ knots, one set will be supplied by the Barrow works of the company and two sets by Parsons Marine Steam Turbine Company, Ltd.

DURING the past month, the British Electricity Authority has placed contracts for equipment for power stations, transforming stations and transmission lines amounting in the aggregate to £13,516,471. The principal contracts include:—Brighton "B" power station, six 320 k.lb/hr. boilers (Babcock and Wilcox, Ltd.); East Yelland power station, near Barnstaple, four 180 k.lb/hr. boilers (John Thompson Water-Tube Boilers, Ltd.); Tilbury power station, three 540 k.lb/hr. boilers (John Thompson Water-Tube Boilers, Ltd.) and circulating water valves (J. Blakeborough and Sons, Ltd.); Goldington power station, Bedford, generator and station transformers (Hackbridge and Hewittic Company, Ltd.); Ince power station, near Ellesmere Port, structural steelwork (Horseley Bridge and Thos. Piggott, Ltd.); Bold power station, St. Helens, superstructure for main and ancillary buildings (John Laing and Son, Ltd.); Thornhill power station, near Dewsbury, condensing and feed heating plant (Vickers-Armstrongs, Ltd.); Stella South power station, near Newcastle, three 550 k.lb/hr. boilers (Clarke Chapman and Co., Ltd.); Stella North power station, near Newcastle, three 550 k.lb/hr. boilers (Clarke Chapman and Co., Ltd.); Chadderton power station, Oldham, superstructure to main buildings (J. Jarvis and Sons, Ltd.); and Huncoat power station, Accrington, three 305 k.lb/hr. boilers (Simon Carves, Ltd.).

Personal and Business

FENTER, Ltd., Birmingham, has been appointed world agent for Denbigh milling and drilling machines, metal saws and presses.

THE METROPOLITAN-VICKERS ELECTRICAL EXPORT COMPANY, Ltd., announces the appointment of Mr. F. C. Gray, A.M.I.Mech.E., as manager for Spain.

MR. D. M. REES has been appointed chairman of the South-Western Divisional Coal Board in succession to Mr. G. E. Aeron-Thomas, who retired at the end of last year.

MR. G. P. BELSHAM has been appointed a joint managing director of Brookhirst Switchgear, Ltd., Chester. Mr. K. N. Swash, A.M.I.E.E., chief engineer of the company, has been appointed a director.

E. K. COLE, Ltd., states that Mr. W. M. York, publicity manager, has been appointed an executive director of the company. Mr. J. E. Furley has been appointed assistant publicity manager and Mr. Michael Kaye, press officer.

MESSRS. FULLER, HORSEY, SONS AND CASSELL are moving their offices to 10, Lloyds Avenue, London, E.C.3, on March 1st. The premises at 10, Billiter Square, which are being vacated, have been in the firm's occupation since 1807.

MR. E. C. DAVIES, A.M.I.E.E., has been appointed manager of the heavy plant section of the engineering sales department of the General Electric Company, Ltd., Wiston, in succession to Mr. H. Nielsen. Mr. G. F. J. Morgan has been appointed assistant manager of the section.

MR. A. J. W. GRAHAM, M.I.C.E., M.I.Mech.E., has resigned his position as technical controller with Messrs. Sandberg, 40, Grosvenor Gardens, London, S.W.1, but is continuing his other activities. His private address is Western House, Middleton-one-Row, Darlington (telephone, Dinsdale 54).

THE MINISTRY OF CIVIL AVIATION states that Mr. S. L. Hulme has been appointed Northern Divisional Controller, at the Ministry's Liverpool headquarters, in succession to Captain B. L. Huskisson, R.N. (Ret.), who has become chairman of the Air Traffic Control Development Staff.

MR. F. A. KIMBERLEY, managing director of the James Cycle Company, Ltd., has been re-elected president of the British Cycle and Motor Cycle Manufacturers' and Traders' Union. Mr. J. Y. Sangster, of the Triumph Engineering Company, Ltd., and Mr. H. Evan Price, of the Dunlop Rubber Company, Ltd., have been re-elected vice-presidents.

British Patent Specifications

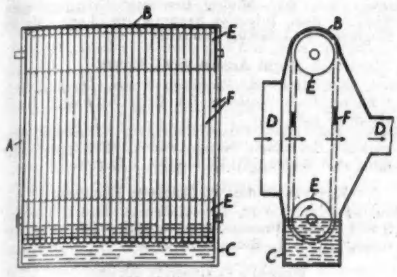
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

INTERNAL COMBUSTION ENGINES

664,326. October 3, 1949.—A New Air Cleaner for Motor Vehicles, Albion Motors, Ltd., and Edward Brian Stead, both of South Street, Scotstoun, Glasgow, W.4.

Referring to the drawing, the rectangular filter casing *A* consists of two parallel side plates joined at the top by a semi-cylindrical cover *B* and by an oil reservoir *C* at the bottom. At the front and back are covers with ducts *D* to lead the air to and from the filter. At the top and bottom of the casing are grooved transverse rollers *E* in the grooves of which are mounted helical spring garters *F* forming a row of endless belts trained around the rollers and just contacting with one another, the garters at the

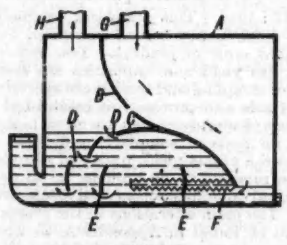


No. 664,326

ends of the row contacting the side walls of the casing. Where they pass over the top roller the garters are just clear of the cover, while at the bottom they dip into the oil reservoir. The spring garter length is set so as to present gaps between adjacent convolutions or to be of such a pitch that oil on the convolutions does not completely close the gaps. The size of the gaps can thus be readily made to suit different conditions. In operation the air passes through two areas of oil-wetted coils and in so doing gives up a large proportion of dust. Arrangements for driving the garters are also described in the specification.—*January* 2, 1952.

664,317. September 19, 1949.—Gas Scrubbers, The Hunslet Engine Company, Ltd., of Jack Lane, Leeds, 10; and John Frederick Alcock, of the company's address.

This invention describes an improved gas scrubber for the exhaust gases of diesel locomotive engines. Referring to the drawing, a chamber *A* containing an adequate volume of water in its lower part, is divided into two compartments by a combined partition *B* and baffle *C*. The two compartments communicate with each other beneath the baffle. In one side of the baffle are gas outlet



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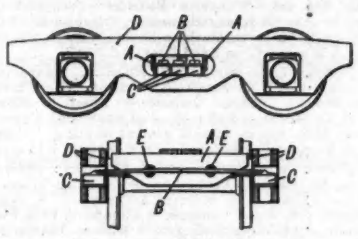
orifices *D*. One or more guide vanes *E* may be provided within the baffle to promote the desired swirling action. Further, there is arranged horizontally across the part of the region enclosed by the baffle a grid *F* of fine mesh of expanded metal, extending from one of the lower edges of the baffle across about one-half of the compartment. One of the compartments has a gas inlet *G* and the other a gas outlet *H*. A closed branch connection through which water can be introduced is provided. The exhaust gases admitted through *G* and caused to pass beneath the grid *F* at the edge attached to the baffle *C* first flow upwardly through the grid and, by impinging against the concave underside of the baffle set up a swirling motion in the water. This causes the water, with its entrained gases, to be circulated repeatedly through the grid and within the baffle before the scrubbed gases escape through the orifices *D* to an outlet *H*. In this condition the pressure of the gas in the right-hand compartment depresses the level of water in that compartment and correspondingly raises the level in the other compartment, as shown in the drawing. With a reversal of flow of the gases resulting from a reversal of the engine, causing air from the engine to pass into the discharge compartment, the water is displaced from one compartment into the other, but with resumption of the normal action of the engine the water returns to the gas discharge compartment.—*January* 2, 1952.

RAILWAY ENGINEERING

664,466. September 2, 1949.—Bogies, Erik Hedin, 10, Strandgatan, Eskilstuna, Sweden.

The invention relates to a spring device for four-wheel bogies in which the swing bolster is supported by bending springs to provide an improved construction in which the springs supporting the bolster also guide it in the lateral direction. As shown in the upper view, the swing bolster *A* is supported by three springs *B*, the ends of which rest on rubber members *C* in the frame *D* of the bogie. The lower view shows a section through the bolster



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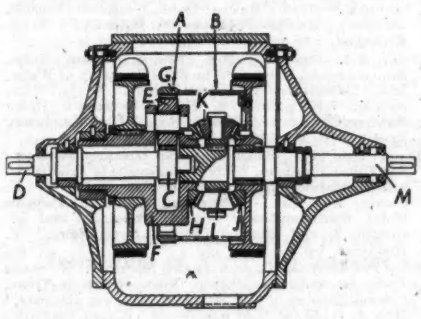
and the frame of the bogie. The springs *B* extend through holes in two bars *E*, which at their ends are mounted in the walls of the bolster. The bars are fixed at equal distances from the centres of the springs. As the ends of the springs rest on the rubber members, the bolster can have smooth limited movement in the lateral direction. Further, the rubber pads prevent, to a large degree, the transmission of sound and vibrations from the frame of the bogie to the bolster. The invention is not limited to a certain number or construction of springs.—*January* 9, 1952.

POWER TRANSMISSION

664,641. June 10, 1949.—Epicyclic Reversing Gear, Wilhelm Gustav Stoeckicht, 4, Rugendasstrasse, München-Solln, Germany.

The gear illustrated in the drawing consists of a spur wheel epicyclic gear *A*, which is connected with a bevel wheel epicyclic gear *B*. The spur wheel gear consists of an inner central wheel or sun wheel *C*, which is mounted fast upon the driving shaft *D* and is in mesh with planet pinions *E* mounted in a planet carrier *F*. The epicyclic pinions are also in mesh with an outer central wheel *G*. The second set



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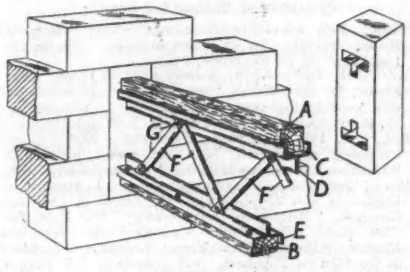
of sun and planet wheels *B* consists of two central bevel wheels *H* and *J*, of the same size, and which are in mesh with epicyclic bevel pinions *K* mounted in a planet carrier *L* on the driven shaft *M*. The planet carrier *F* of the epicyclic set *A* is connected fast with one central wheel *H* of the epicyclic set *B*, while the outer central wheel *G* of the epicyclic set *A* is connected fast with the second central wheel *J* of the set *B*, by a drum and a brake disc. The planet carrier *F*, and with it the central wheel *H*, are connected with a brake disc, which can be held fast. Similarly the outer central wheel *G*, and with it the drum and the central wheel *J*, can be held fast by means of a braking appliance acting on the disc. The drum and the brake disc form a casing in which the epicyclic set *B* is enclosed. In the specification a modified form of gear with both epicyclic gears constructed as spur gear is shown and the method of operation of both forms of gear described.—*January* 9, 1952.

CIVIL ENGINEERING

664,714. June 10, 1949.—Joists and Beams, S. Crowther (Royton), Ltd., Royton Ironworks, Milton Street, Royton, near Oldham, Lancashire, formerly of Axis Works, Royton, near Oldham; and Reginald Taylor, of the company's address.

As shown in the accompanying drawing, the beam comprises upper and lower longitudinal wooden members *A* and *B*, of which the upper is of somewhat greater cross-section than the lower. A sheet metal channel member *C* partially encloses the lower half of the upper member and its part *D* projecting downwardly is secured by screws or nails. A similar channel member *E* is secured to the lower wooden member. A number of short sheet metal channel members *F* are arranged in a zigzag manner at an angle of about 45 deg. to the longi-



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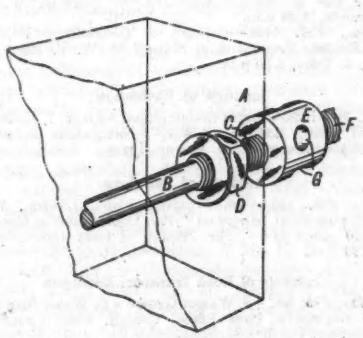
tudinal members *A* and *B*, their ends overlapping the projecting parts. One of the two members *F*, which meet at a point, overlap the other and may be secured by rivets *G* or by bolts or welding. They can be arranged at any angle up to and including a right angle. The beam can be anchored in a wall by means of concrete blocks, similar to that shown which has T-shaped apertures to receive the ends of the channel members. Anchoring plates may be attached to the sides of the channel members at the ends of the beam, for securing them to the other structural members.—*January* 9, 1952.

664,458. July 18, 1949.—Reinforced Structural Members, McCalls Macalloy, Ltd., Templeborough, Rotherham, Yorkshire. (*Inventor: Donovan Henry Lee.*)

This invention relates to the prestressing of concrete, cast iron and other materials. The accompanying drawing shows part of a concrete block *A*, which has a reinforcing rod *B* in it. The rod is threaded at *C* for a sufficient length to receive a nut *D* which bears against the end of the block and a



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threaded collar *E* to which is secured the shaft *F* of a jack for applying tension to the rod reinforcement. The nut *D* is tightened up as the tensioning of the rod by the jack continues, until the prestressing is completed, when the jack and collar are disconnected. The invention provides, it is claimed, a method of prestressing rod or bar reinforcement in concrete or other materials relatively weak in tension.—*January* 9, 1952.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Supervising Electrical Engineers

To-day, Feb. 8th.—BRISTOL BRANCH: Grand Hotel, Bristol, "Automobile Welding Repairs," A. Gilliard, 7.30 p.m.——CREWE BRANCH: Copeland Arms Hotel, Glebe Street, Stoke, "Industrial Lighting," V. Heydon, 7.30 p.m.——LIVERPOOL BRANCH: Lecture Theatre Service Centre, 9, Whitechapel, Liverpool, lecture and film, "Distinguished Company," 7.30 p.m.

Tues., Feb. 19th.—Lighting Service Bureau, 2, Savoy Hill, London, W.C.2, "Scope and Application of Metal Rectifiers," Donald Ashby, 6.30 p.m.

British Institution of Radio Engineers

Wed., Feb. 13th.—N.E. SECTION: Neville Hall, Westgate Road, Newcastle upon Tyne, symposium of papers by student members, 6 p.m.——S. MIDLANDS SECTION: Corporation Street Civic Restaurant, Coventry, "Gas Discharge Devices as Switching Elements," E. A. R. Peddle, 7.15 p.m.

Thurs, Feb. 14th.—SCOTTISH SECTION: Natural Philosophy Department, The University, Edinburgh, Clerk-Maxwell Memorial Lecture, G. W. O. Howe, 7 p.m.

Illuminating Engineering Society

To-day, Feb. 8th.—BIRMINGHAM CENTRE: Imperial Hotel, Temple Street, Birmingham, "Industrial Lighting," E. H. Norgrove, 6 p.m.

Tues., Feb. 12th.—Royal Society of Arts, John Adam Street, London, W.C.2, "Specification and Testing of Fluorescent Lighting Fittings and Components," W. R. Bloxsidge, G. Fahey and D. T. Waigh, 6 p.m.

Wed., Feb. 13th.—EDINBURGH CENTRE: Lighting and Cleansing Department, 357, High Street, Edinburgh, "Outdoor Decorative Lighting," H. Carpenter, 7 p.m.

Thurs., Feb. 14th.—GLASGOW CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Brightness Engineering," W. Robinson, 6.30 p.m.——LEICESTER CENTRE: E. Midlands Electricity Board, Charles Street, Leicester, "Lighting of the 'Queen Elizabeth' and 'Caronia,'" T. Catten, 6.30 p.m.——MANCHESTER CENTRE: Town Hall Extension, Manchester, "Lighting and Vision in Advancing Age," H. C. Weston, 6 p.m.

Incorporated Plant Engineers

Tues., Feb. 12th.—E. LANCS BRANCH: Engineers' Club, Albert Square, Manchester, "Aspects on the Use of Creosote Pitch as Boiler Fuel," S. C. Swann, 7.15 p.m.——S. WALES BRANCH: Institute of Engineers, Park Place, Cardiff, "Aspects and Problems of Modern Pumping Machines," J. F. Copp, 7.15 p.m.

Thurs., Feb. 14th.—KENT BRANCH: Queen's Head Hotel, Maidstone, "Utilisation of Refrigeration in War," 7 p.m.——NEWCASTLE UPON TYNE BRANCH: Roadway House, Oxford Street, Newcastle upon Tyne, "Mechanical Equipment at Colombo Harbour," C. K. Moore, 7.30 p.m.

Institute of Industrial Supervisers

Tues., Feb. 12th.—KIDDERMINSTER SECTION: Carpet Trades, Ltd., Mill Street, Kidderminster, "Industrial Relations," T. Wylie, 7.30 p.m.

Thurs., Feb. 14th.—COVENTRY SECTION: Craven Arms Hotel, High Street, Coventry, "Internal Transport as it Affects Factory Production," A. E. Humphreys, 7.30 p.m.

Institute of Marine Engineers

Tues., Feb. 12th.—85, Minories, London, E.C.3, "Fuels for Use in Marine Auxiliary Oil Engines," C. D. Brewer, 5.30 p.m.

Thurs., Feb. 14th.—College of Technology, Belfast, "Electric Propulsion of Ships," M. W. T. Rees and G. J. Tuke, 7.30 p.m.

Institute of Navigation

Fri., Feb. 15th.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Navigation Aids for Military Aircraft," D. Bower, 5 p.m.

Institute of Petroleum

Wed., Feb. 13th.—26, Portland Place, London, W.1, symposium of papers on "The Lubrication of Gears," 2.30 p.m.; and "The Testing of Gear Lubricants," 5.30 p.m.

Institute of Road Transport Engineers

To-day, Feb. 8th.—S. WALES GROUP: S. Wales Institute of Engineers, Park Place, Cardiff, open discussion meeting, 7 p.m.

Tues., Feb. 12th.—WESTERN GROUP: Grand Hotel, Bristol, "Tyre Development and the Use and Abuse of Tyres," W. R. Good, 7.30 p.m.

Wed., Feb. 13th.—E. MIDLANDS CENTRE: Mechanics' Institute, Nottingham, "Some Aspects of Motor Racing and Engine Design," Bob Gerard and Reg. Parnell, 7.30 p.m.

Institution of Chemical Engineers

Tues., Feb. 12th.—Geological Society, Burlington House, London, W.1, "Operation of the Dutch State Mines Cyclone as a Separator of Minerals," K. A. Fern, 5.30 p.m.

Institution of Civil Engineers

Tues., Feb. 12th.—Great George Street, Westminster, S.W.1, "The Construction of Sloy Dam," James Stevenson, 5.30 p.m.

Thurs., Feb. 14th.—N.W. ASSOCIATION: Engineers' Club, Albert Square, Manchester, "The Dome of Discovery, Festival of Britain Site," Gilbert Roberts, 6.30 p.m.——MIDLANDS ASSOCIATION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Highway Design and Lay-out," R. W. Grigson, 6 p.m.

Institution of Electrical Engineers

Mon., Feb. 11th.—Savoy Place, London, W.C.2, discussion on "Merit Rating and Job Evaluation," opened by J. J. Gracie, 5.30 p.m.

Tues., Feb. 12th.—Central Hall, Westminster, S.W.1, Faraday Lecture on "Sound Recording—Home, Professional, Industrial and Scientific Applications," G. F. Dutton, 6.30 p.m.

Wed., Feb. 13th.—RADIO SECTION: Savoy Place, London, W.C.2, "Factors Affecting the Design of the Automatic Electron Trajectory Tracer," K. F. Sander, C. W. Oatley and J. G. Yates, 5.30 p.m.——SCOTTISH CENTRE: Heriot-Watt College, Edinburgh, "The London-Birmingham Television Radio Relay Link," R. J. Clayton, C. Epsley, G. W. S. Griffiths, and J. M. C. Pinkham, 7 p.m.

Institution of Engineers and Shipbuilders in Scotland

Tues., Feb. 12th.—39, Elmbank Crescent, Glasgow, "Simplified Launching Calculations," A. Silverleaf, 6.30 p.m.

Institution of Mechanical Engineers

To-day, Feb. 8th.—WESTERN BRANCH: Technical College, Brunswick Road, Gloucester, "Industrial Design and its Relation to Machine Design," H. G. Conway, 7 or 7.30 p.m. (to be fixed later).

Mon., Feb. 11th.—SOUTHERN BRANCH, GRADUATES' SECTION: B.E.A. Southern Division, High Street, Portsmouth, "Early Generating Plant in Ships," G. H. O. Holland, 5.45 p.m.——LUTON A.D. CENTRE: Town Hall, Luton, annual general meeting, "Carbon as an Engineering Material," D. B. Foster, 7.15 p.m.

Tues., Feb. 12th.—AUTOMOBILE DIVISION: Storey's Gate, St. James's Park, London, S.W.1, "Noise in Private Cars," J. R. Bristow, 5.30 p.m.——S. WALES BRANCH: S. Wales Institute of Engineers, Park Place, Cardiff, "Air Conditioning in a Modern Textile Factory," R. G. Clarke and J. P. Russell, 6.15 p.m.

Wed., Feb. 13th.—N.W. BRANCH: Liverpool Engineering Society, 24, Dale Street, Liverpool, "Ship Research," S. Livingston Smith, 6 p.m.

Fri., Feb. 15th.—Storey's Gate, St. James's Park, London, S.W.1, "The Allocation of Machines to Operators," T. F. O'Connor, 5.30 p.m.——N.E. BRANCH, GRADUATES' SECTION: Neville Hall, Westgate Road, Newcastle upon Tyne, "Water Power," C. W. D. Carradice, 6.30 p.m.

Institution of Post Office Electrical Engineers

Tues., Feb. 12th.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Some Applications of Cold Cathode Tubes in Switching Circuits," J. A. Lawrence, 5 p.m.

Institution of Production Engineers

To-day, Feb. 8th.—EASTERN COUNTIES SECTION: Public Library, Northgate Street, Ipswich, "Electronic Control of Machine Tools and Self-Regulating Systems," R. Parr, 7.30 p.m.

Mon., Feb. 11th.—MANCHESTER GRADUATE SECTION: College of Technology, Manchester, "The Mass Production of Furniture," N. Grey, 7.15 p.m.——SHEFFIELD SECTION: Royal Victoria Station Hotel, Sheffield, "Precision Instruments," C. A. Coppack, 6.30 p.m.——YORKSHIRE SECTION: Hotel Metropole, Leeds, "Air in Industry," T. R. Mobbs, 7 p.m.

Tues., Feb. 12th.—BIRMINGHAM GRADUATE SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Increasing Productivity—with Special Reference to the Role of the Executive and the Consultant in Industry," E. C. Gordon England, 7 p.m.——DUNDEE SECTION: Mathers Hotel, Whitehall Crescent, Dundee, "Human Relations in Industry," W. P. Kirkwood, 7.45 p.m.

Wed., Feb. 13th.—PRESTON SECTION: Swan Hotel, Bradshawgate, Bolton, "The Steel Company of Wales, Ltd.—Developments at Port Talbot," W. G. Mainwaring, 7.15 p.m.——S. ESSEX SECTION: Ilford Bowling Club, near Ilford Station, "High-Frequency Heating," R. H. Barfield, 7.30 p.m.

Thurs., Feb. 14th.—ROCHESTER AND DISTRICT SECTION: Sun Hotel, Chatham, "The Organisation of Production Administration for Higher Productivity," B. E. Stokes, 7.30 p.m.——SOUTHERN SECTION: Polygon Hotel, Southampton, "Thread Production and Inspection," and film, "They're Everywhere," F. Hodgkins, 7 p.m.

Fri., Feb. 15th.—STOKE-ON-TRENT SECTION: N. Staffs Technical College, Cauldon Place, Stoke-on-Trent, "Some Aspects of the Study of Working Methods," Miss A. G. Shaw, 7.30 p.m.——W. WALES SECTION: Central Library, Alexandra Road, Swansea, "Recent Developments in Plastics," E. M. Elliott, 7.30 p.m.

Institution of Structural Engineers

Wed., Feb. 13th.—WALES AND MONMOUTHSHIRE BRANCH: Mackworth Hotel, Swansea, "Completed Abertillery Bridge," Wallace A. Evans, 6.30 p.m.

Thurs., Feb. 14th.—11, Upper Belgrave Street, London, S.W.1, "The Fire Endurance of Timber Beams and Floors," D. I. Lawson, C. T. Webster and L. A. Ashton, 5.55 p.m.——LANCASHIRE AND CHESHIRE BRANCH: Engineers' Club, Albert Square, Manchester, "The Dome of Discovery, Festival of Britain Site," Gilbert Roberts, 6.30 p.m.

Junior Institution of Engineers

To-day, Feb. 8th.—39, Victoria Street, London, S.W.1, "Modern Submarine Cables," E. A. Applebee, 6.30 p.m.

Fri., Feb. 15th.—39, Victoria Street, London, S.W.1, "Recent Developments in Arc Welding Electrodes," D. H. Young, 6.30 p.m.

Liverpool Engineering Society

Wed., Feb. 13th.—24, Dale Street, Liverpool, "Ship Research," S. Livingston Smith, 6 p.m.

Liverpool Metallurgical Society

To-day, Feb. 8th.—The University, Brownlow Street, Liverpool, "Some Technical and Economic Problems in the Conservation of Fuel," A. L. Roberts.

Manchester Association of Engineers

To-day, Feb. 8th.—College of Technology, Manchester, annual lecture, F. C. Williams, 6.45 p.m.

Manchester Geological and Mining Society

Thurs., Feb. 14th.—Mining and Technical College, Library Street, Wigan, "Reconstruction at Chisnall Hall Colliery," P. Gaskell, 3.15 p.m.

Ministry of Works

Tues., Feb. 12th.—Bristol University, Royal Fort, Bristol, 8, "Structural Use of Steel in Buildings," G. A. Gardner, 7 p.m.

North-East Coast Institution of Engineers and Shipbuilders

To-day, Feb. 8th.—Mining Institute, Newcastle upon Tyne, "Fuel Injection Systems for Large Marine Engines," P. Jackson, 6.15 p.m.

Royal Aeronautical Society

Tues., Feb. 12th.—4, Hamilton Place, London, W.1, "Flight Test Problems for Civil Aircraft," B. P. Laight, 7 p.m.

Thurs., Feb. 14th.—GRADUATES AND STUDENTS' SECTION: 4, Hamilton Place, London, W.1, lecture and films on "Radar," B. W. Hodlin, 7.30 p.m.

Royal Institution of Chartered Engineers

Mon., Feb. 11th.—12, Great George Street, London, S.W.1, "Some Practical Aspects of New Town Development," Bryan L. Richards, 5.30 p.m.

Women's Engineering Society

Wed., Feb. 13th.—MANCHESTER BRANCH: Visit to Connolly's (Blackley), Ltd., Manchester, 6.30 p.m.

Fri., Feb. 15th.—35, Grosvenor Place, London, S.W.1, "Organisation—The Women's Engineering Society," 7 p.m.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

EMERGENCY SPECIFICATIONS FOR CASE HARDENING STEELS

Addendum No. 1 to No. 970 : 1951. As a result of the present serious shortages of alloying elements for steel, the Steel (Rearmament) Panel of the Ministry of Supply has under consideration the problem of economy in the use of such elements by the replacement of specifications in which their content is relatively high by others stipulating a much lower content. For this reason eight specifications designated En.351, 352, 353, 354, 355, 361, 362 and 363, covering case-hardening steels, have now been published in this addendum to B.S. 970. They are intended as an emergency measure to replace the case-hardening steels En. 33, 34, 35, 36, 37, 38, 39 and 325, of B.S. 970 : 1947. Price 1s., post free.

CALCIUM CARBIDE (GRADED SIZES)

No. 642 : 1951. This standard, originally published in 1935, is now issued in revised form and covers eight sizes of grading. Test requirements for dust, gas yield and impurities are stated and methods of sampling and testing are specified. Conditions of sale and purchase as established by the British Acetylene Association are given in Appendix B. The methods of sampling, and those for the determination of gas yield, purity of acetylene and impurities required to be brought up to date, and the Technical Committee concerned recommended its revision. The main alterations in the revised standard are to be found in Appendix A, in which new apparatus and improved methods for the determination of gas yield and impurities have been included. The specification section now stipulates that the carbide shall yield gas containing not less than 99 per cent by volume of acetylene, instead of 96 per cent as in the original standard. Limits for arsenic and nitrogen compounds have been added to those for sulphur and phosphorus. Appendix B remains unaltered, except that the amounts of gas yield below which claims and rights of refusal are allowed have been slightly increased for all sizes below 15mm to accord with the tolerance of minus 5 per cent specified in Clause 5.

During the preparation of the standard the Committee had the co-operation of the Dominion interests concerned and of the associated European manufacturers of carbide. Price 4s. post free.